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Bibliography of Recent Research in the Field of High Polymers

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This new Circular concisely summarizes the activities of the National Bureau of Standards in the plastics field. The program is presented under 8 separate headings relating to as many different lines of investigation. A bibliography of 160 references to publications by members of the Bureau staff is given.

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by Robert Simha, Irma G. Callomon, Mary Budge Gaughan, and
Helen H. Jeppson



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INTRODUCTION

This bibliography, which supersedes National Bureau of Standards Letter Circular LC922 (October 1948), contains a reference list of papers that appeared in American and foreign scientific periodicals. The former cover the period January 1946 to December 1949, inclusive. The foreign journals included were those available up to January 1, 1950, in the Library of this Bureau. English periodicals are incorporated from 1945, Russian periodicals from 1943, Japanese periodicals from 1941, and the remainder from 1944. In some cases older issues have been included.

The literature included deals with fundamental investigations of the chemistry and physics of certain classes of natural and synthetic organic high polymers. The very nature of this project makes completeness an almost impossible task. Furthermore, it is often difficult to draw the line between research of a so-called fundamental and applied character. Thus, important material may have been omitted. Nevertheless, this bibliography should fulfill two purposes: first, to provide a source of reference for the active worker in the fields covered, and, second, to assist those concerned with related subjects in keeping informed of recent developments.

The material is arranged according to the main lines of research on high polymers currently being pursued. In some sections of the first part, dealing with physical properties of bulk materials, the various classes of high polymers are treated separately. No such division is warranted in the remainder of the bibliography according to modern concepts of high polymer theory.

The number of subdivisions is considerably extended in the current review. In division 100, Physical Properties of Bulk Materials, a section on optical investigations has been added. In 200, Solutions and Gels, there appear sections on polyelectrolytes, sorption of and swelling by gases and liquids, rheological properties of concentrated solutions, and adhesion. In 300, Reactions, subdivisions on bulk, solution and emulsion polymerization, and copolymerization have been included. These extensions will facilitate the search for specific articles or authors in a particular field. On the other hand, the increased number of categories increases the probability of incorrect classification and causes some difficulties when several subjects are treated in the same paper.

In this connection, conflicts between sections, such as solution polymerization and copolymerization or viscosity and osmotic pressure may be mentioned. In these and similar cases, the principle purposes and aspects of the article have been taken into consideration. Even so, the decision is somewhat arbitrary and the reader may disagree in several instances. The same is true in respect to the various sections called "general".

The preparation and properties of monomers are not considered here. Strictly speaking, substances such as proteins or starches should be included in such a review. The same is true for articles dealing with leather or paper as such. Here, however, some of the details of experimental techniques and theoretical approaches are different, and research in these fields is sufficiently specialized to justify exclusion from this bibliography. It is realized that such a procedure may eliminate studies that are of importance to polymer work in general. On the other hand, a few articles dealing with the general theory of transport phenomena in liquids have been included. Strictly speaking, they do not belong in this bibliography. However, because of their generality and perhaps due to the authors' personal preference, they appear here.

Books, such as *High polymer physics*,¹ *Proceedings of the second rubber technology conference, London 1948*,² *Proceedings of the International Rheological Congress, Holland 1948*,³ booklets, theses, and periodicals dealing with specific types of polymers are not covered in this bibliography. To include them would greatly increase the bulk of the bibliography without correspondingly increasing its usefulness. However, for the benefit of students and specialists in other fields who may be approaching the study of high polymers for the first time, we are listing some examples of pertinent periodicals and abstract services. This list is neither complete nor highly critical, but should be representative of the current literature and includes sources that will be found useful.

¹ Remsen Press Division, Chemical Publishing Co., Inc., Brooklyn, N. Y., 1948.

² W. Heffer & Sons, Ltd., London, England, 1949.

³ North Holland Publishing Co., Amsterdam, Holland, 1949. Obtainable at Interscience Publishers, Inc., 215 Fourth Ave., New York 3, N. Y.

PERIODICALS DEALING WITH SPECIFIC TYPES OF POLYMERS

Rubber

Rubber chemistry and technology reprints literature on rubber judged to be of permanent scientific value. Foreign papers are translated into English. Published quarterly by the Rubber Division of the American Chemical Society, Prince and Lemon Sts., Lancaster, Pa.

Research Association of British Rubber Manufacturers. Summary of current literature. Scientific, technical, trade, and patent literature on rubber is thoroughly covered. Publications more difficult to obtain, such as Russian and Japanese, are abstracted in detail to eliminate reference to the original articles. Published monthly by the Association, 105 Lansdowne Road, Croydon, England.

National Bureau of Standards Letter Circular LC626 (January 15, 1941) by A. T. McPherson, represents a guide to the literature on rubber.

Plastics

Modern plastics covers current developments in the plastics industry and presents abstracts of papers. Published monthly by Modern Plastics, Inc., 122 E. 42d St., New York 17, N. Y.

British plastics, official organ of the Plastics Industry. Published monthly by the Iliffe and Sons, Ltd., Dorset House, Stamford St., London, S.E.1, England.

Plastics (London) covers papers dealing with the manufacture, uses, and potentialities of plastic materials. Published monthly by Temple Press, Ltd., Bowling Greene Lane, London E.C.1, England.

National Bureau of Standards Letter Circular LC975 (January 13, 1950) by G. M. Kline, contains references to a series of books and periodicals in the field of plastics.

Textiles

Textile research journal covers fundamental and applied research and presents abstracts of papers. Official publication of the Textile Research Institute, Inc., and The Textile Foundation. Published monthly at Prince and Lemon Sts., Lancaster, Pa.

Journal of the Textile Institute, official journal for communications released for publication by various British research organizations. Abstracts are presented. Published monthly by the Textile Institute, St. Mary's Parsonage, Manchester, England.

The Journal of the Society of Dyers and Colourists, official publication of the Society. Covers original work and presents abstracts of foreign papers and patents. Published monthly, 32 Piccadilly, Bradford, Yorkshire, England.

Abstract Services

Resins—rubbers—plastics. A loose-leaf abstract service covering chemical, physical, and technological aspects of these materials. Published monthly by the Interscience Publishers, Inc., 215 Fourth Ave., New York 3, N. Y.

Natural and synthetic fibers. A loose-leaf literature and patent abstract service covering chemical, physical, and technological aspects of these materials as well as patent applications. Issued monthly in cooperation with Milton Harris Associates, Washington, D. C. and the Polymer Research Institute, Polytechnic Institute of Brooklyn. Published by Interscience Publishers, Inc., 215 Fourth Ave., New York 3, N. Y.

100. PHYSICAL PROPERTIES OF BULK MATERIALS

101. RUBBERS

- R. D. Andrews, N. Hofman-Bang, and A. V. Tobolsky, Elastoviscous properties of polyisobutylene. I. Relaxation of stress in whole polymer of different molecular weights at elevated temperatures. *J. Polymer Sci.* **3**, 669 (1948).
- R. D. Andrews, A. V. Tobolsky, and E. E. Hanson, Theory of permanent set at elevated temperatures in natural and synthetic rubber vulcanizates. *J. Applied Phys.* **17**, 352 (1946).
- G. M. Bartenev, High-elastic properties of vulcanized butadiene-styrene rubber. *Kolloid. Zhur.* **11**, 57 (1949).
- J. R. Beatty and J. M. Davies, Time and stress effects in the behavior of rubber at low temperature. *J. Applied Phys.* **20**, 533 (1949).
- A. M. Borders and R. M. Pierson, Particle size in latex as related to synthetic rubber properties and high-solids latex fluidity. *Ind. Eng. Chem.* **40**, 1473 (1948).
- W. F. Busse, J. M. Lambert, and R. B. Verdery, Tackiness of GR-S and other elastomers. *J. Applied Phys.* **17**, 376 (1946).
- L. E. Cheyney, Plasticizers for polar synthetic rubbers. *Ind. Eng. Chem.* **41**, 670 (1949).
- F. S. Conant, G. L. Hall, and G. R. Thurman, Relationship between Gough-Joule coefficients and moduli of vulcanized rubbers. *J. Applied Phys.* **20**, 526 (1949).
- E. M. Dannenberg, Carbon black loaded GR-S stocks. Relationship between reinforcement and swelling properties. *Ind. Eng. Chem.* **40**, 2199 (1948).
- J. D. D'Ianni, Physical properties of diene polymers. *Ind. Eng. Chem.* **40**, 253 (1948).
- F. W. Dittman and C. C. Winding, Thermal properties of GR-S latices. *Ind. Eng. Chem.* **41**, 543 (1949).
- B. Dogadkin, K. Pechkovskaya, and M. Dashevskii, Structure and properties of filled rubber mixtures. III. Mixtures of sodium butadiene rubber with channel black. *Kolloid. Zhur.* **10**, 357 (1948).
- D. G. Fisher, Molecular structure and arrangement in stretched natural rubber. *Proc. Phys. Soc. (London)* **60**, 99 (1948).
- H. L. Fisher, Elastomers, a review. *Ind. Eng. Chem.* **39**, 1210 (1947); **40**, 1788 (1948); **41**, 2115 (1949).
- P. J. Flory, Effects of molecular structure on physical properties of butyl rubber. *Ind. Eng. Chem.* **38**, 417 (1946).
- P. J. Flory, Effects of cross-linking and branching on the molecular constitution of diene polymers. *J. Am. Chem. Soc.* **69**, 2893 (1947).
- P. J. Flory, N. Rabjohn, and M. C. Shaffer, Dependence of elastic properties of vulcanized rubber on the degree of cross-linking. *J. Polymer Sci.* **4**, 225 (1949).
- P. J. Flory, N. Rabjohn, and M. C. Shaffer, Dependence of tensile strength of vulcanized rubber on degree of cross-linking. *J. Polymer Sci.* **4**, 435 (1949).
- P. D. Galloway and W. C. Wake, Direct estimation of polymer and carbon black in vulcanized butyl rubber (GR-I). *Analyst* **71**, 505 (1946).
- S. D. Gehman, D. E. Woodford, and C. S. Wilkinson, Low-temperature characteristics of elastomers. *Ind. Eng. Chem.* **39**, 1108 (1947).
- S. D. Gehman, Creep, recovery, and permanent set for GR-S and Hevea. *J. Applied Phys.* **19**, 456 (1948).
- R. S. Haverhill, H. C. O'Brien, and J. J. Rankin, Electrostatic and tensile properties of rubber and GR-S at elevated temperatures. *J. Applied Phys.* **17**, 338 (1946).
- A. Ishihara, Abnormal melting of raw rubber. *J. Phys. Soc. Japan* **3**, 19 (1948).
- B. L. Johnson, Effect of molecular weight distribution on physical properties of natural and synthetic polymers. *Ind. Eng. Chem.* **40**, 351 (1948).
- R. D. Juve and J. W. Marsh, Low-temperature behavior of butadiene-styrene copolymers. *Ind. Eng. Chem.* **41**, 2535 (1949).
- V. A. Kargin and T. I. Sogolova, Study of viscous flow of polyisobutylene. *J. Phys. Chem. (USSR)* **23**, 551 (1949).

- P. O. Kinell, Elasticity measurements on polychloroprenes. *J. Phys. & Colloid Chem.* **51**, 70 (1947).
- C. H. Klute, Some remarks concerning a proposed method for testing the brittleness of elastomers. *J. Applied Phys.* **19**, 1093 (1948).
- W. Kuhn and O. Künzle, Experimental determination of the dynamic viscosity, elasticity, and the relaxation-time spectrum of rubber. *Helv. Chim. Acta* **30**, 839 (1947).
- W. Kuhn, O. Künzle, and A. Preissmann, Distribution of relaxation times, elasticity, and viscosity of rubber. I. *Helv. Chim. Acta* **30**, 307 (1947). II. **30**, 464.
- W. Kuhn, R. Pasternak, and H. Kuhn, Mechanical and optical properties of swollen rubber. *Helv. Chim. Acta* **30**, 1705 (1947).
- F. Levi and H. J. Philipp, Velocity of sound in rubber. *Helv. Phys. Acta* **21**, 233 (1948).
- H. K. Livingston, Stability of synthetic rubber dispersions. I. Low-temperature thickening of Neoprene latex. *J. Phys. & Colloid Chem.* **51**, 443 (1947).
- J. W. Livingston, Cold rubber development. *Chem. Eng. News* **27**, 2444 (1949).
- F. S. Malm, Hard rubber, a review. *Ind. Eng. Chem.* **39**, 1243 (1947); **40**, 1809 (1948); **41**, 2138 (1949).
- W. C. Mast and C. H. Fisher, Lactoprene EV elastomer. *Ind. Eng. Chem.* **41**, 703 (1949).
- A. W. Meyer, Effects of polymerization temperature on structure. *Ind. Eng. Chem.* **41**, 1570 (1949).
- M. Mochulsky and A. V. Tobolsky, Chemorheology of polysulfide rubbers. *Ind. Eng. Chem.* **40**, 2155 (1948).
- M. Mooney, The rheology of processing quality of raw rubbers. *J. Colloid Sci.* **2**, 69 (1947).
- R. E. Morris and J. W. Hollister, Carbon black dispersion in rubber. *Ind. Eng. Chem.* **40**, 2325 (1948).
- M. Oota, Physical-mechanical properties of vulcanized rubber containing different types of rubber. *Anais. assoc. quim. Brasil* **6**, 203 (1947).
- R. Pasternak and W. Kuhn, Experimental investigations on swollen, vulcanized rubber. *Helv. Chim. Acta* **31**, 340 (1948).
- J. Rehner, Jr., Elastic deformation and molecular weight in polyisobutylene. *J. Polymer Sci.* **1**, 225 (1946).
- J. Rehner, Jr., Heat conduction and molecular structure in rubberlike polymers. *J. Polymer Sci.* **2**, 263 (1947).
- F. Rössler, Flow phenomena in rubber samples. *Z. angew. Physik* **1**, 50 (1948).
- G. Salomon and C. Koningsberger, Preparation and properties of rubberlike high polymers. IV. Correlation between structure and properties of elastomers derived from dienes. *J. Polymer Sci.* **2**, 522 (1947); Errata, **3**, 95 (1948).
- G. Salomon, Preparation and properties of rubberlike high polymers. V. Influence of nitrile groups on the properties of copolymers. *J. Polymer Sci.* **3**, 32 (1948).
- A. H. Scott, Directional effects in dielectric properties of molded rubber. *J. Research NBS* **43**, 355 (1949) RP2030.
- M. D. Stern and A. V. Tobolsky, Stress-time-temperature relations in polysulfide rubbers. *J. Chem. Phys.* **14**, 93 (1946).
- P. B. Stickney and L. E. Cheyney, Plasticizers for rubbers and resins. *J. Polymer Sci.* **3**, 231 (1948).
- L. R. G. Treloar and R. F. Naylor, Physical and chemical aspects of rubber technology. *Nature* **162**, 204 (1948).
- A. J. Wildschut, On the proportion of crystalline and amorphous components in stretched vulcanized rubber. *J. Applied Phys.* **17**, 51 (1946).
- L. A. Wood and N. Bekkedahl, Crystallization of unvulcanized rubber at different temperatures. *J. Applied Phys.* **17**, 362 (1946).
- J. A. Yanko, Physical properties of fractions of GR-S and their vulcanizates. *J. Polymer Sci.* **3**, 576 (1948).
- R. L. Zapp and F. P. Baldwin, Effect of polymolecularity on deformation of butyl polymers. *Ind. Eng. Chem.* **38**, 948 (1946).

102. PLASTICS

- W. Aiken, T. Alfrey, Jr., A. Janssen, and H. Mark, Creep behavior of plasticized Vinylite VYNW. *J. Polymer Sci.* **2**, 178 (1947).
- T. Alfrey, Jr., and M. Berdick, Isolation and purification of polyvinyl acetate. *J. Polymer Sci.* **3**, 899 (1948).
- T. Alfrey, Jr., N. Wiederhorn, R. Stein, and A. Tobolsky, Plasticized polyvinyl chloride. *Ind. Eng. Chem.* **41**, 701 (1949).
- T. Alfrey, Jr., N. Wiederhorn, R. Stein, and A. Tobolsky, Some studies of plasticized polyvinyl chloride. *J. Colloid Sci.* **4**, 211 (1949).
- K. F. Beal and C. J. B. Thor, Water-soluble alkoxyacetals of polyvinyl alcohol. *J. Polymer Sci.* **1**, 540 (1946).
- R. W. Bentz and H. A. Neville, Water content of hydrophilic phenol formaldehyde resins: Vapor pressure-temperature relationships. *J. Polymer Sci.* **4**, 673 (1949).
- E. R. Blout and R. Karplus, The infrared spectrum of polyvinyl alcohol. *J. Am. Chem. Soc.* **70**, 862 (1948).
- R. P. Bowman, J. S. Fitzgerald, and F. M. Jensen, The water absorption of phenol-formaldehyde resin moldings. *J. Council Sci. Ind. Research* **20**, 503 (1947).
- A. Brown, X-ray diffraction studies of the stretching and relaxing of polyethylene. *J. Applied Phys.* **20**, 552 (1949).
- R. Buchdahl and H. K. Nason, Rheological problems in the processing of plastics. *Ind. Eng. Chem.* **40**, 642 (1948).
- R. Buchdahl, Rheology of thermoplastic materials. I. Polystyrene. *J. Colloid Sci.* **3**, 87 (1948).
- W. F. Busse, J. M. Lamber, C. McKinley, and H. R. Davidson, Polyvinyl carbazole resin as a dielectric material. *Ind. Eng. Chem.* **40**, 2271 (1948).
- A. Charlesby, Structure and orientation in thin films of polythene. *Proc. Phys. Soc. (London)* **57**, 496 (1945).
- G. F. Daletskii, Anisotropy in oriented polystyrene. *Compt. rend. acad. sci. URSS* **54**, 311 (1946).
- G. J. Dienes, Viscoelastic properties of thermoplastics at elevated temperatures. *J. Colloid Sci.* **2**, 131 (1947).
- G. J. Dienes and F. D. Dexter, Notes on "The viscous flow of molten polystyrene" by Spencer and Dillon. *J. Colloid Sci.* **3**, 181 (1948).
- G. J. Dienes, Flow properties of phenolic resins. *J. Colloid Sci.* **4**, 257 (1949).
- G. J. Doyle and R. M. Badger, The viscoelastic behavior of a highly plasticized nitrocellulose in compression under constant load. *J. Applied Phys.* **19**, 373 (1948).
- P. W. Dozlov, The relaxation process in films of cellulose ethers and esters, *Akad. Nauk SSSR* **1**, 12 (1943).
- K. A. Earhart, Theories and facts concerning alkyds. *Ind. Eng. Chem.* **41**, 716 (1949).
- D. D. Eley, Theory of rolling plastics. I. Calculation of roll pressure. *J. Polymer Sci.* **1**, 529 (1946); II. Thermal effects, **1**, 535 (1946).
- P. J. Flory and F. S. Leutner, Occurance of head-to-head arrangements of structural units in polyvinyl alcohol. *J. Polymer Sci.* **3**, 880 (1948).
- H. Funahashi, Copolymer of vinyl chloride and vinyl acetate. II. Mechanical and thermal properties of copolymer. *J. Soc. Chem. Ind. Japan* **47**, 792 (1944).
- H. Funahashi, Stretching of membranes of synthetic high-molecular substances: I. Effect of stretching membranes of polyvinyl chloride and chlorinated polyvinyl chloride on the tensile strength, elongation, and Young's modulus; II. Effect of stretching membranes of polyvinyl alcohol and polymethyl methacrylate on the tensile strength, elongation, and Young's modulus; III. Effect of stretching membranes of copolymers of vinyl chloride and vinyl acetate and some other synthetic high-molecular substances on the mechanical properties; IV. Consideration as to the mechanism of stretching; V. Effect of stretching polyvinyl alcohol fiber on the process of softening; VI. Effect of the degree of polymerization on the strength, elongation, and Young's modulus of the stretched substances; VII. Effect of stretching of membranes of a synthetic high-molecular substance on the softening process; VIII. Effect of stretching velocity and

- heat treatment on tensile strength and Young's modulus. *J. Soc. Chem. Ind. Japan* **47**, 800 (1944).
- T. S. Gardner, Cellulose acetate esters containing amino nitrogen. *J. Polymer Sci.* **1**, 121 (1946).
- W. M. Gearhart and W. D. Kennedy, Cellulose acetate butyrate plastics. *Ind. Eng. Chem.* **41**, 695 (1949).
- L. Glatt and J. W. Ellis, Infra-red dichroism in aligned polythene and "parowax". *J. Chem. Phys.* **15**, 884 (1947).
- W. E. Gloor, Properties of cellulose as applied in plastic materials. *J. Chem. Education* **24**, 214 (1947).
- W. E. Gloor, Low temperature impact strength of cellulosic plastics. *Ind. Eng. Chem.* **39**, 1125 (1947).
- F. Goldschmidt and B. Dishon, Polymeric phosphonitrile esters: A new type of inorganic-organic plastics. *J. Polymer Sci.* **3**, 481 (1948).
- C. B. Hurd, Study on siloxanes. I. The specific volume and viscosity in relation to temperature and constitution. *J. Am. Chem. Soc.* **68**, 364 (1946).
- N. I. Iznairskaya, X-ray investigation of the process of formation of simple cellulose ethers, particularly of ethylcellulose. *J. Gen. Chem. (USSR)* **17**, 367 (1947).
- K. Kanamaru, N. Daimon, and N. Ohno, Heat effect on chain polymers. II. Heat effect in polyvinyl alcohol. *J. Soc. Chem. Ind. Japan* **47**, 1277 (1943).
- R. H. Kienle, Alkyd resins—development of and contribution to polymer theory. *Ind. Eng. Chem.* **41**, 726 (1949).
- G. M. Kline, Plastics, a review. *Ind. Eng. Chem.* **39**, 1234 (1947); **40**, 1804 (1948); **41**, 2132 (1949).
- C. S. Marvel, R. S. Gander, and R. R. Chambers, Koresin and related resins. *J. Polymer Sci.* **4**, 689 (1949).
- B. Maxwell and L. F. Rahm, Rheological properties of polystyrene below 80°C. *Ind. Eng. Chem.* **71**, 1988 (1949).
- J. J. McGovern, J. M. Grin, and W. C. Teach, Determination of monomer in polystyrene. Spectrophotometric and solubility methods. *Anal. Chem.* **20**, 312 (1948).
- N. J. L. Megson, Molecular structure and its influence on the properties of phenolic resins. *J. Soc. Chem. Ind. (London)* **67**, 155 (1948).
- E. Merz, L. Nielsen, and R. Buchdahl, Influence of molecular weight on the properties of polystyrene. I. Mechanical properties of polystyrene films cast from solvents. *J. Polymer Sci.* **4**, 605 (1949).
- L. W. A. Meyer and W. M. Gearhart, Cellulose ester plastics. *Ind. Eng. Chem.* **40**, 1478 (1948).
- W. P. Moeller and N. Taylor, Effect of humidity on properties of plasticized ethylcellulose. *Ind. Eng. Chem.* **39**, 1149 (1947).
- H. W. Moll and W. J. Le Fevre, Some temperature-Young's modulus relationships for plastics. *Ind. Eng. Chem.* **40**, 2172 (1948).
- S. K. Mukherjee, Recent developments in plastics. Silicones, the organo-silicone high polymers. *J. Indian Chem. Soc., Ind. and News Ed.* **9**, 93 (1946).
- W. F. O. Pollett, Thermally reversible strains in plasticized polyvinyl chloride. *J. Soc. Chem. Ind. (London)* **66**, 319 (1947).
- M. C. Reed, Survey of plasticizers for vinyl resins. *J. Polymer Sci.* **2**, 115 (1947).
- M. C. Reed and J. Harding, Plasticizers in vinyl chloride-acetate resins. *Ind. Eng. Chem.* **41**, 675 (1949).
- R. B. Richards, The structure and properties of ethylene polymers. *J. Inst. Petroleum* **34**, 237 (1948).
- D. K. Rider, J. K. Sumner, and R. J. Myers, Properties of plasticized polyvinyl chloride compositions. *Ind. Eng. Chem.* **41**, 709 (1949).
- H. A. Rigby and C. W. Bunn, A room-temperature transition in polytetrafluoroethylene. *Nature* **164**, 583 (1949).
- J. A. Sauer, J. Marin, and C. C. Hsiao, Creep and damping properties of polystyrene. *J. Applied Phys.* **20**, 507 (1949).
- C. E. Schildknecht, S. T. Gross, H. R. Davidson, J. M. Lambert, and A. O. Zoss, Polyvinyl isobutylethers—properties and structures. *Ind. Eng. Chem.* **40**, 2104 (1948).
- R. S. Spencer and R. E. Dillon, The viscous flow of molten polystyrene. *J. Colloid Sci.* **3**, 163 (1948); **II**, **4**, 241 (1949).

- R. S. Spencer, Volume-temperature-time relationships for polystyrene. *J. Colloid Sci.* **4**, 229 (1949).
- R. S. Spencer and G. D. Gilmore, Equation of state for polystyrene. *J. Applied Phys.* **20**, 502 (1949).
- S. Tsuruta, Urea-formaldehyde resins. IV. Decomposition temperatures and behavior toward some reagents of acid-catalized powdery resins. *J. Soc. Chem. Ind. Japan* **44**, 915 (1941).
- A. J. Warner, Electrical properties of plastics. *ASTM Bulletin* **153**, 60 (1948).
- R. H. Wiley and G. M. Brauer, Polyvinyl chloroacetate. *J. Polymer Sci.* **3**, 708 (1948).

103. FIBROUS MATERIALS

103.1 Animal Fibers

- P. Alexander, D. Carter, and C. Earland, The application of organosilicon polymers to wool. *J. Soc. Dyers Colourists* **65**, 107 (1949).
- A. J. Farnworth and J. B. Speakman, Chemical mechanism of permanent set. *Nature* **161**, 890 (1948).
- A. J. Farnworth and J. B. Speakman, Reactivity of the sulphur linkage in wool. *Nature* **163**, 798 (1949).
- C. J. Gorter and A. L. Houwink, An electron microscope study of the structure of the wool hair. *Proc. Neder. Acad.* **51**, 262 (1948).
- J. Lindberg and N. Gralén, Influence of some anti-shrink treatments on the friction between wool fibers. *Nature* **162**, 112 (1948).
- J. Lindberg, B. Philip, and N. Gralén, Occurrence of thin membranes in the structure of wool. *Nature* **162**, 458 (1948).
- M. Lipson, A new method for forming vinyl polymers in wool. *Nature* **164**, 576 (1949).
- M. Lipson and J. B. Speakman, Formation of polymers in textile fibers. *Nature* **157**, 590 (1946).
- M. Lipson and J. B. Speakman, Use of polymers to immunize wool against acid dyes. *Nature* **157**, 736 (1946).
- M. Swerdlow and G. S. Seeman, A method for the electron microscopy of wool. *J. Research NBS* **41**, 231 (1948).

103.2 Plant Fibers

- K. Banerjee and K. A. Ray, The structure of jute fiber by X-ray diffraction method. *Proc. Natl. Inst. Sci. India* **1**, 377 (1941).
- E. E. Berkley and T. Kerr, Structure and plasticity of undried cotton fibers. *Ind. Eng. Chem.* **38**, 304 (1946).
- C. R. Bose and N. Ahmad, A study of some vegetable fibers by X-ray diffraction methods. *Indian J. Phys.* **20**, 105 (1946).
- E. Husemann, Macromolecular compounds. CCCXIX. Cellulose. 90. Sub-microscopic structural elements of cellulose fibers. *Cellulosechem.* **22**, 132 (1944).
- E. Husemann and A. Carnap, Distribution of weak bonds in the cellulose molecules of fibers. *Naturwissenschaften* **32**, 79 (1944).
- W. G. Kinsinger and C. W. Hock, Electron microscopic studies of natural cellulose fibers. *Ind. Eng. Chem.* **40**, 1711 (1948).
- G. Lindeberg, Tensile strength and chemical composition of the middle lamella of the flax fiber. *Experientia* **4**, 476 (1948).

103.3 Synthetic Fibers

- C. E. Black, III, and M. Dole, Density of undrawn, drawn, and annealed nylon filaments. *J. Polymer Sci.* **3**, 358 (1948).
- A. Bréguet, R. Viatte, and H. Perra, Absorption and fixation of NaOH from solution by regenerated (viscose) cellulose. *Compt. rend.* **227**, 204 (1948).
- W. Braschede, Spherulite structure of synthetic high polymers. *Kolloid-Z.* **114**, 35 (1949).
- C. W. Bunn and E. V. Garner, The crystal structure of two polyamides (nylon). *Proc. Roy. Soc. (London) A* **189**, 39 (1947).

- W. E. Catlin, E. P. Czerwin, and R. H. Wiley, Multi-ingredient polyamides. *J. Polymer Sci.* **2**, 412 (1947).
- G. Champetier and R. Aelion, Influence of hydrogen bonds on the properties of polyamides. *Bull. soc. chim. France* **1948**, 683.
- D. D. Coffman, G. J. Berchet, W. R. Peterson, and E. W. Spanagel, Polymeric amides from diamines and dibasic acids. *J. Polymer Sci.* **2**, 306 (1947).
- D. D. Coffman, N. L. Cox, E. L. Martin, W. E. Mochel, and F. J. Van Natta, Polymeric amides from omega-amino acids. *J. Polymer Sci.* **3**, 85 (1948).
- K. Fuchino and I. Sakurada, Studies of synthetic polyamides by means of X-rays. *Sci. Papers Inst. Phys. Chem. Research (Tokyo)* **40**, 125 (1942).
- W. E. Hanford and R. M. Joyce, Polymeric amides from epsilon-caprolactam. *J. Polymer Sci.* **3**, 167 (1948).
- K. Hess and H. Kiessig, Long-period interferences and micellar fiber-fine structure of synthetic polymers (polyamides and polyesters). *Z. physik. Chem.* **193**, 196 (1944).
- K. Hoshino, The deaeration of viscose. *J. Soc. Chem. Ind. Japan* **45**, 1071 (1942).
- E. Husemann, Electron microscopic investigations of submicroscopic fibrils of synthetic fibers. *Makromol. Chem.* **1**, 158 (1947).
- H. G. Ingersoll, Fine structure of viscose rayon. *J. Applied Phys.* **17**, 924 (1946).
- K. Kanamaru, N. Daimon, and N. Ohno, Heat effect on chain polymers. I. Heat effect in regenerated cellulose. *J. Soc. Chem. Ind. Japan* **46**, 1277 (1943).
- K. Kanamaru and F. Oyama, Relation between the distribution of polymerization degrees and the mechanical properties of chain-like molecules. II. Relation between the distribution of polymerization degrees and the tensile strength of nylon. *J. Soc. Chem. Ind. Japan* **46**, 1273 (1943).
- W. Kast and A. Prietzschk, X-ray investigations of the stretching and the structure of rayon fibers. *Kolloid-Z.* **114**, 23 (1949).
- C. Legrand, Effect of water on mercerized cellulose. *Compt. rend.* **227**, 529 (1948).
- C. M. Langkammerer and W. E. Catlin, Spherulite formation in polyhexamethylene adipamide. *J. Polymer Sci.* **3**, 305 (1948).
- K. Lauer, O. Wilde, and O. Dobberstein, Information on liquid states of cellulose xanthates in viscose. *Kolloid-Z.* **112**, 16 (1949).
- E. L. Lovell and O. Goldschmid, Rayon structure. *Ind. Eng. Chem.* **38**, 811 (1946).
- W. J. Lyons, The general relations for flow in solids and their application to the plastic behavior of tire cord. *J. Applied Phys.* **17**, 472 (1946).
- R. L. Mitchell, Viscose processing of cellulose. Changes in basic properties. *Ind. Eng. Chem.* **41**, 2197 (1949).
- G. M. Moelter and E. Schweizer, Heat softening of cellulose acetate. *Ind. Eng. Chem.* **41**, 684 (1949).
- M. Nagano, The mechanical properties of cellulose and its derivatives. I. Relations between fatigue and the degree of polymerization of the natural and hydrated cellulose. *J. Soc. Chem. Ind. Japan* **46**, 802 (1943); II. Relations between the degree of polymerization and the elasticities or viscosities of rayon. **46**, 806 (1943).
- H. Ohe, Some properties of viscose rayon. *J. Soc. Chem. Ind. Japan* **45**, 980 (1942).
- T. Petitpas, The influence of physical treatments on the structure of cellulose and of mercerized cellulose. *Mém. services chim. état (Paris)* **33**, 95 (1947).
- J. Putnik, Nylon. *Chemie (Prague)* **3**, 10 (1947).
- I. Sakurada and K. Fuchino, X-ray studies of synthetic high-molecular compounds in fiber form. *Sci. Papers Inst. Phys. Chem. Research (Tokyo)* **39**, 78 (1941).
- A. Sippel, The variation of tensile strength and degree of polymerization of synthetic fibers through irradiation and the relation of the phenomenon to the molecular structure, especially of cellulose derivatives. *Kolloid-Z.* **112**, 80 (1949).
- E. Steurer, Deformation and recrystallization in lattice-ordered high-polymer substances. *Z. Naturforsch.* **2b**, 275 (1947).

- H. Wakeham and E. Honald, Hysteresis and related elastic properties of tire cords. *J. Applied Phys.* **17**, 698 (1946).
 L. M. Welch, W. E. Roseveare, and H. Mark, Fibrillar structure of rayon fibers. *Ind. Eng. Chem.* **38**, 580 (1946).
 E. L. Wittbecker, R. C. Houtz, and W. W. Watkins, Elastic N-substituted polyamides. *Ind. Eng. Chem.* **40**, 875 (1948).
 A. J. A. Van der Wyk and K. H. Meyer, Atomic configuration of cellulose. *J. Polymer Sci.* **2**, 583 (1947).

103.4 General

- F. E. Bartell, W. R. Purcell, and C. G. Dodd, The measurement of the effective pore size and of the water-repellency of tightly woven textiles. *Discussions Faraday Soc.* **1948**, No. 3, 257.
 E. Blanchard Castillo, Physicochemical study of cellulose, viscose, and fibers. IV. *Anales fis. y quím. (Madrid)* **42**, 149 (1947).
 G. Bozza, Physics of textile fibers. *Riv. nuovo cimento* **3**, 79 (1947).
 R. S. Casey and C. S. Grove, Jr., Fibers, a review. *Ind. Eng. Chem.* **39**, 1213 (1947); **40**, 1793 (1948); **41**, 2119 (1949).
 R. C. Darling and H. S. Belding, Moisture adsorption of textile yarns at low temperatures. *Ind. Eng. Chem.* **38**, 524 (1946).
 L. Flaschner and W. Kast, X-ray investigation of the relationship of crystalline and amorphous substances in cellulose fibers. *Naturwissenschaften* **34**, 56 (1947).
 D. Fornelli, Animalization of cellulosic fibers. *Am. Dyestuff Repr.* **37**, 853 (1948).
 C. J. Geyer, Jr., C. H. Reichardt, and G. Halsey, A theory of commercial yarn testing. *J. Applied Phys.* **19**, 464 (1948).
 I. J. Gruntfest and D. D. Gagliardi, Wrinkle resistance of fabrics. *Ind. Eng. Chem.* **41**, 760 (1949).
 H. Haas, Investigations of the morphological and chemical structure of cellulose fibers from wood. *Makromol. Chem.* **3**, 117 (1949).
 P. H. Hermans and D. Vermaas, Density of cellulose fibers. I. Introduction and experiments on the penetration of liquids into dry cellulose. *J. Polymer Sci.* **1**, 149 (1946).
 P. H. Hermans, J. J. Hermans, and D. Vermaas, Density of cellulose fibers. II. Density and refractivity of model filaments. *J. Polymer Sci.* **1**, 156 (1946); III. Density and refractivity of natural fibers and rayon. **1**, 162 (1946).
 P. H. Hermans and A. Weidinger, Change in crystallinity upon heterogeneous acid hydrolysis of cellulose fibers. *J. Polymer Sci.* **4**, 317 (1949).
 R. Hill and E. E. Walker, Polymer constitution and fiber properties. *J. Polymer Sci.* **3**, 609 (1948).
 H. G. Ingersoll and A. A. Johnson, Ionic exchange and fiber contraction. *Nature* **162**, 225 (1948).
 W. Kast, L. Flaschner, and E. Winkler, Orientation and strength of cellulose fibers. *Kolloid-Z.* **111**, 1 (1948).
 W. Kast and L. Flaschner, An X-ray method for determination of the proportion of crystalline and amorphous substance in cellulose fibers. *Kolloid-Z.* **111**, 6 (1948).
 K. Lauer, W. Mansch, and B. Meske, Cellulose fibers. 9. Elastic properties of cellulose fibers. *Kolloid-Z.* **112**, 110 (1949).
 F. C. Magne, H. J. Portas, and H. Wakeham, A calorimetric investigation of moisture in textile fibers. *J. Am. Chem. Soc.* **69**, 1896 (1947).
 S. M. Neale and R. H. Peters, Electrokinetic measurements with textile fibers and aqueous solutions. *Trans. Faraday Soc.* **42**, 478 (1946).
 R. F. Nickerson and J. A. Habrle, Cellulose intercrystalline structure. *Ind. Eng. Chem.* **39**, 1507 (1947).
 J. W. Rowen and R. L. Blaine, Sorption of nitrogen and water vapor on textile fibers. *Ind. Eng. Chem.* **39**, 1659 (1947).
 R. Signer and M. Roth, Simple method for the measurement of water evaporation through layers of different textile fibers. *Makromol. Chem.* **3**, 281 (1949).
 H. Staudinger, P. Herrbach, and H. Stock, The structure of natural and synthetic cellulose fibers. *Makromol. Chem.* **1**, 60 (1947).

- S. Tessler, N. T. Woodberry, and H. Mark, Application of the density-gradient tube in fiber research. *J. Polymer Sci.* 1, 437 (1946).
 J. S. Tinsley, A summary of recent developments in cellulose and cellulose derivatives. *J. Chem. Education* 25, 94 (1948).
 H. A. Vreedenberg, Elastic properties of textile yarns, represented with the aid of a mechanical model. *J. Polymer Sci.* 1, 329 (1946).
 C. S. Whewell, Modern methods of fiber investigation. *Nature* 159, 379 (1947).
 J. Whitney, X-ray diffraction as a tool in the study of textile fibers. *The Frontier* 11, 18 (1948).

104. GENERAL

104.1 Structure

- N. L. Alpert, Studies of the solid state by means of nuclear magnetism. *Phys. Rev.* 72, 637 (1947).
 N. L. Alpert, Study of phase transitions by means of nuclear magnetic resonance phenomena. *Phys. Rev.* 75, 398 (1949).
 H. Benoit, The statistics of chains with interactions and steric hindrances. *J. chim. phys.* 44, 18 (1947).
 H. Benoit, Calculation of the deviation of the quadratic mean between the ends of a molecular chain. *J. Polymer Sci.* 3, 376 (1948).
 H. Benoit and C. Sadron, Statistics of chain molecules in dilute solutions. *J. Polymer Sci.* 4, 473 (1949).
 R. C. Briant, Volume effect and random flights. *J. Chem. Phys.* 16, 839 (1948).
 C. W. Bunn, Molecular structure and physical properties of polymers. *Research (London)* 1, 630 (1948).
 J. T. Clarke and E. R. Blout, Nature of carbonyl groups in polyvinyl alcohol. *J. Polymer Sci.* 1, 419 (1946).
 M. J. Duclaux and A. M. Biget, Density of solid high-polymers. *J. chim. phys.* 45, 137 (1948).
 P. J. Flory, Configuration of real polymer chains. *J. Chem. Phys.* 17, 303 (1949).
 C. A. Hollingsworth, The average boundaries of statistical chains. *J. Chem. Phys.* 16, 544 (1948).
 C. A. Hollingsworth, Transverse boundary of the random coil. *J. Chem. Phys.* 17, 97 (1949).
 C. Koningsberger, Study of the structure of macromolecules by organic chemical methods. *Chem. Weekblad* 45, 118 (1949).
 R. Kubo, Statistical theory of linear polymers. I. Intramolecular statistics. *J. Phys. Soc. Japan* 2, 47 (1947); IV. Effect of hindrance for internal rotation; 3, 119 (1948).
 H. Kuhn, Restricted bond rotation and shape of unbranched saturated hydrocarbon chain molecules. *J. Chem. Phys.* 15, 843 (1947).
 H. Kuhn, The dimension of a statistically coiled chain molecule in any direction. *Helv. Chim. Acta* 31, 1677 (1948).
 W. Kuhn, Dependence of the average transversal on the longitudinal dimensions of statistical coils formed by chain molecules. *J. Polymer Sci.* 1, 380 (1946).
 F. H. Müller, The association types of high polymers and their relationship to the physical properties. *Kolloid-Z.* 108, 66 (1944).
 B. Pullman, Electronic structure of polyethylene hydrocarbons. *Compt. rend.* 225, 61 (1947).
 C. Sadron, Statistics of long chain molecules under consideration of energy effects. *J. chim. phys.* 43, 142 (1946).
 C. E. Schildknecht, S. T. Gross, and A. D. Zoss, Isomerism in vinyl and related polymers. *Ind. Eng. Chem.* 41, 1998 (1949).
 R. Simha, Note on volume effect in coiling molecules. *J. Research NBS* 40, 21 (1948); *J. Polymer Sci.* 3, 227 (1948).
 H. Staudinger, Natural and synthetic polymers. *Makromol. Chem.* 1, 7 (1947).
 W. J. Taylor, Average length and radius of normal paraffin hydrocarbon molecules. *J. Chem. Phys.* 16, 257 (1948).

- W. J. Taylor, Average square length and radius of unbranched long-chain molecules with restricted internal rotation. *J. Chem. Phys.* **15**, 412 (1947).
 L. R. G. Treloar, The statistical length of long-chain molecules. *Trans. Faraday Soc.* **42**, 77 (1946).
 B. H. Zimm, and W. H. Stockmayer, The dimensions of chain molecules containing branches and rings. *J. Chem. Phys.* **17**, 1301 (1949).

104.2 Thermodynamic Investigations

- A. P. Aleksandrov, The crystallization and crystallizing force of polymers. *Akad. Nauk SSSR* **1**, 7 (1943).
 A. P. Aleksandrov, The resistance to cold of high-molecular compounds. *Akad. Nauk SSSR* **2**, 49 (1944).
 W. O. Baker and C. S. Fuller, Thermal evidence of crystallinity in linear polymers. *Ind. Eng. Chem.* **38**, 272 (1946).
 K. Bates, Thermal conductivity of liquid silicones. *Ind. Eng. Chem.* **71**, 1966 (1949).
 N. Bekkedahl, Volume dilatometry. *J. Research NBS* **43**, 145 (1949).
 R. F. Boyer and R. S. Spencer, Effect of plasticizers on second-order transition points of high polymers. *J. Polymer Sci.* **2**, 157 (1947).
 A. Charlesby, Effect of temperature on the structure of highly polymerized hydrocarbons. *Proc. Phys. Soc. (London)* **57**, 510 (1945).
 L. E. Copeland, The thermodynamics of a strained elastomer. II. Compressibility. *J. Applied Phys.* **19**, 445 (1948).
 L. E. Copeland and M. Mooney, The thermodynamics of a strained elastomer. III. The thermal coefficient of modulus and the statistical theory of elasticity. *J. Applied Phys.* **19**, 450 (1948).
 R. D. Evans, H. R. Mighton, and P. J. Flory, Thermodynamics of crystallization in high polymers. III. Dependence of melting points of polyesters on molecular weight and composition. *J. Chem. Phys.* **15**, 685 (1947).
 P. J. Flory, Thermodynamics of crystallization in high polymers. I. Crystallization induced by stretching. *J. Chem. Phys.* **15**, 397 (1947); II. Simplified derivation of melting-point relationships; **15**, 684 (1947); IV. A theory of crystalline states and fusion in polymers, copolymers, and their mixtures with diluents; **17**, 223 (1949).
 T. G. Fox, P. J. Flory, and R. E. Marshall, Thermodynamics of crystallization in high polymers. VI. Incipient crystallization in stretched vulcanized rubber. *J. Chem. Phys.* **17**, 704 (1949).
 E. Guth, P. E. Wack, and R. L. Anthony, Significance of the equation of state for rubber. *J. Applied Phys.* **17**, 347 (1946).
 W. H. Hamill, B. A. Mrowca, and R. L. Anthony, Specific heats of Hevea, GR-S, and GR-I stocks. *Ind. Eng. Chem.* **38**, 106 (1946).
 H. S. Kaufman, A. Sacher, T. Alfrey, Jr., and I. Fankuchen, Side-chain crystallization in alkyl polyacrylates. *J. Am. Chem. Soc.* **70**, 3147 (1948).
 H. J. Kolb and E. F. Izard, Dilatometric studies of high polymers. I. Second order transition temperatures. *J. Applied Phys.* **20**, 564 (1949); II. Crystallization of aromatic polyesters; **20**, 571 (1949).
 V. E. Lucas, P. H. Johnson, L. B. Wakefield, and B. L. Johnson, Dilatometric measurement of molecular regularity in polymers. *Ind. Eng. Chem.* **41**, 1629 (1949).
 A. Mayor, Variation in the specific heat of rubber as a function of elongation. *Experientia* **3**, 26 (1947).
 A. R. Mayor and C. G. Boissonnas, Variation of the specific heat of rubber as a function of elongation. *Helv. Chim. Acta* **31**, 1514 (1948).
 G. S. Parks and J. R. Mosley, The heats of combustion of polythene and polyisobutylene. *J. Chem. Phys.* **17**, 699 (1949).
 W. Parks and R. B. Richards, The effect of pressure on the volume, thermodynamic properties, and crystallinity of polythene. *Trans. Faraday Soc.* **45**, 203 (1949).
 S. J. Singer, Note on an equation of state for linear macromolecules in monolayers. *J. Chem. Phys.* **16**, 872 (1948).
 R. S. Spencer and R. F. Boyer, Thermal expansion and second-order transition effects in high polymers. III. Time effects. *J. Applied Phys.* **17**, 398 (1946).

V. V. Tarasov, Theory of low-temperature heat capacity of linear macromolecules. *Compt. rend. acad. sci. URSS* **46**, 20 (1945).

104.3 Elasticity and Flow

- N. F. Astbury, Some theoretical considerations on the dynamic properties of plastics. *Proc. Roy. Soc. (London)* **A 196**, 92 (1949).
- J. W. Ballou and J. C. Smith, Dynamic measurements of polymer physical properties. *J. Applied Phys.* **20**, 493 (1949).
- M. Born and H. S. Green, A general kinetic theory of liquids. III. Dynamical properties. *Proc. Roy. Soc. (London)* **A 190**, 455 (1947).
- M. Born, Kinetic theory of diffusion in gases and liquids. I. Diffusion and the Brownian motion. *Proc. Roy. Soc. (London)* **A 198**, 94 (1949).
- R. F. Boyer, The compatability, efficiency, and permanence of plasticizers. *J. Applied Phys.* **20**, 540 (1949).
- E. G. Chilton, Large deformation of an elastic solid. *J. Applied Mechanics* **15**, 362 (1948).
- J. Clouaire, Hysteresis in crystallizable elastomers. *J. phys. radium* **10**, 295 (1949).
- L. E. Copeland and M. Mooney, Thermal coefficients of modulus and the statistical theory of elasticity. III. *J. Applied Phys.* **19**, 450 (1948).
- J. K. Craver, The mechanism of plasticization in plastics. *ASTM Bulletin* **152**, 90 (1948).
- G. J. Dienes and F. D. Dexter, Resin-plasticizer systems. *Ind. Eng. Chem.* **40**, 2319 (1948).
- G. J. Dienes and H. F. Klemm, Theory and application of the parallel plate plastometer. *J. Applied Phys.* **17**, 458 (1946).
- A. K. Doolittle, Application of a mechanistic theory of solvent action to plasticizers and plasticization. *J. Polymer Sci.* **2**, 121 (1947).
- H. Eyring and G. Halsey, Some recent advances in non-Newtonian viscosity. *J. Colloid Sci.* **2**, 17 (1947).
- G. Fournet, A generalization of the Born and Green theory of liquids to mixtures of different molecules. *Compt. rend.* **229**, 1071 (1949).
- K. Goldsmith and J. Iball, The measurement of the rheological properties of visco-plastic substances. *Proc. Phys. Soc. (London)* **62**, 251 (1949).
- J. H. Greenblatt and D. Fensom, Extrusion properties of high polymers with included crystalline filler. *Ind. Eng. Chem.* **39**, 1037 (1947).
- B. Gross, On creep and relaxation. *J. Applied Phys.* **18**, 212 (1947); **II**, 19, 257 (1948).
- G. Halsey, Non-linear viscous elasticity and the Eyring shear model. *J. Applied Phys.* **18**, 1072 (1947).
- C. B. Havens, Plasticizing linear polymers. *J. Colloid Sci.* **4**, 347 (1949).
- W. Heller and H. Oppenheimer, Comparative studies on photoelasticity of elastomers and plastomers. *J. Colloid Sci.* **3**, 33 (1948).
- J. J. Hermans, The behavior of rubber-like materials when stretched. *J. Colloid Sci.* **1**, 235 (1946).
- K. W. Hillier and H. Kolsky, An investigation of the dynamic elastic properties of some high polymers. *Proc. Phys. Soc. (London)* **62**, 111 (1949).
- K. W. Hillier, H. Kolsky, and J. P. Lewis, Method of measuring dynamic mechanical properties of rubber-like materials. *J. Applied Phys.* **20**, 227 (1949).
- M. L. Huggins, A new approach to the theory of rubberlike elasticity. *J. Polymer Sci.* **1**, 1 (1946).
- D. G. Ivey, B. A. Mrowca, and E. Guth, Propagation of ultrasonic bulk waves in high polymers. *J. Applied Phys.* **20**, 486 (1949).
- H. M. James, Statistical properties of networks of flexible chains. *J. Chem. Phys.* **15**, 651 (1947).
- H. M. James, Network theory of rubber elasticity. *Record Chem. Progress* **10**, 173 (1949).
- H. M. James and E. Guth, Theory of increase in rigidity of rubber during cure. *J. Chem. Phys.* **15**, 669 (1947).
- H. M. James and E. Guth, Simple presentation of network theory of rubber with a discussion of other theories. *J. Polymer Sci.* **4**, 153 (1949).
- H. Jones, Temperature sensitivity of the system plasticizer-polymer. *J. Soc. Chem. Ind. (London)* **67**, 415 (1948).

- H. Jones and E. Chadwick, Physicochemical aspects of plasticizer action. *J. Oil and Colour Chemists' Assoc.* **30**, 199 (1947).
- V. A. Kargin, Structural processes in the flow of high polymers. *Akad. Nauk SSSR* **1**, 10 (1943).
- V. A. Kargin, Mechanism of lengthening and shortening of oriented polymers. *Akad. Nauk SSSR Sovenchanie po Belku* **1948**, 118.
- V. A. Kargin and G. L. Slonimskii, Deformation of amorphous-liquid linear polymers. *Doklady Akad. Nauk SSSR* **62**, 239 (1948).
- V. A. Kargin and G. L. Slonimskii, Determination of the molecular weight of linear polymers from their mechanical properties. *J. Phys. Chem. (USSR)* **23**, 563 (1949).
- V. A. Kargin and T. I. Sogolova, The three physical states of amorphous-liquid linear polymers. *J. Phys. Chem. (USSR)* **23**, 530 (1949).
- V. A. Kargin and T. I. Sogolova, Elaboration of a method for studying the true process of flow in polymers. *J. Phys. Chem. (USSR)* **23**, 540 (1949).
- J. G. Kirkwood, Elastic loss and relaxation times in cross-linked polymers. *J. Chem. Phys.* **14**, 51 (1946).
- J. G. Kirkwood, Statistical mechanical theory of transport processes. I. General theory. *J. Chem. Phys.* **14**, 180 (1946); III. The coefficients of shear and bulk viscosity in liquids; **17**, 988 (1949).
- H. Kolsky and A. C. Shearman, Investigation of fractures produced by transient stress waves. *Research (London)* **2**, No. 8, Suppl. 384 (1949).
- R. Kubo, Statistical mechanics of chain substances. I. A model consideration of the elasticity of rubber. *J. Phys.-Math. Soc. Japan* **17**, 273 (1943).
- R. Kubo, Statistical theory of linear polymers. II. Elasticity of vulcanized rubber. *J. Phys. Soc. Japan* **2**, 51 (1947).
- R. Kubo, Statistical theory of rubber-like substances. *J. Colloid Sci.* **2**, 527 (1947).
- W. Kuhn, Relaxation-time spectrum of systems represented by any large number of elastic and frictional mechanisms acting partly in series and partly in parallel. *Helv. Chim. Acta* **30**, 487 (1947).
- W. Kuhn and F. Grün, Statistical behavior of the single chain molecule and its relation to the statistical behavior of assemblies consisting of many chain molecules. *J. Polymer Sci.* **1**, 183 (1946).
- W. Kuhn and H. Kuhn, Interpretation of the internal viscosity of chain molecules. I. *Helv. Chim. Acta* **29**, 609 (1946); II. **29**, 830 (1946).
- W. Kuhn and H. Kuhn, Statistical and energy contributions to the total retractive force in highly extended chain molecules. *Helv. Chim. Acta* **29**, 1095 (1946).
- W. Kuhn and H. Kuhn, Superposition of statistical and energy effects in highly deformed rubber. I. *Helv. Chim. Acta* **29**, 1615 (1946); II. **29**, 1634 (1946).
- P. Laurent and M. Endier, Influence of plastic deformation on the modulus of elasticity. *Compt. rend.* **228**, 225 (1949).
- H. Leaderman, Proposed nomenclature for elastic and inelastic behavior of high polymers. *J. Colloid Sci.* **4**, 193 (1949).
- W. J. Lyons and I. B. Prettyman, Method for the absolute measurement of dynamic properties of linear structures at sonic frequencies. *J. Applied Phys.* **19**, 473 (1948).
- W. S. Macdonald and A. Ushakoff, An instrument for measuring stress relaxation of high polymer materials. *J. Colloid Sci.* **3**, 135 (1948); *Anal. Chem.* **20**, 713 (1948).
- C. Mack, Plastic flow, creep, and stress relaxation. I. Plastic flow. *J. Applied Phys.* **17**, 1086 (1946); II. Creep. **17**, 1093; III. Creep and elastic after-effect. **17**, 1101; IV. Anomalous flow as an order-disorder transition; **19**, 1082 (1948).
- H. Mark, The mechanical properties of high polymers. *Trans. Faraday Soc.* **43**, 447 (1947).
- W. P. Mason, Viscosity and shear elasticity measurements of liquids by means of shear vibrating crystals. *J. Colloid Sci.* **3**, 147 (1948).
- W. P. Mason, W. O. Baker, H. J. McSkimin, and J. H. Heiss, Measurement of shear elasticity and viscosity of liquids at ultrasonic frequencies. *Phys. Rev.* **75**, 936 (1949).
- K. H. Meyer and A. J. A. Van der Wyk, The thermo-elastic properties of rubber. *Helv. Chim. Acta* **29**, 1842 (1946).

- K. H. Meyer and A. J. A. Van der Wyk, The mechanical properties of rubber. *Experientia* **2**, 117 (1946).
- K. H. Meyer and A. J. A. Van der Wyk, Molecular processes during deformation of rubberlike elastic bodies. *J. Polymer Sci.* **1**, 49 (1946).
- R. D. Mindlin, Mathematical theory of photo-viscoelasticity. *J. Applied Phys.* **20**, 206 (1949).
- R. D. Mindlin and L. E. Goodman, Optical equations of three dimensional photoelasticity. *J. Applied Phys.* **20**, 89 (1949).
- M. Mooney, The thermodynamics of a strained elastomer. I. General analysis. *J. Applied Phys.* **19**, 434 (1948).
- D. R. Morey, A theory of viscous deformation in polymers; The volume and surface cohesive energy of the basic moving aggregate. *J. Phys. and Colloid Chem.* **53**, 569 (1949).
- F. H. Müller, Plastic-elastic behavior of materials. III. Structure and mechanism of periodic deformations. *Kolloid-Z.* **114**, 2 (1949).
- F. H. Müller, Cold-stretching of high polymers. *Kolloid-Z.* **114**, 45 (1949).
- G. Natta and M. Baccaredda, Propagation of ultrasonic velocity in macromolecules. *J. Polymer Sci.* **3**, 829 (1948).
- G. Natta and M. Baccaredda, Ultrasonic velocity in macromolecular substances. *J. Polymer Sci.* **4**, 533 (1949).
- L. Nielsen and R. Levreault, Dynamic mechanical properties of polymer-plasticizer systems. *Nature* **164**, 317 (1949).
- H. Nitschmann and J. Schrade, Thread formation in liquids as a phenomenon of anomalous viscosity. *Helv. Chim. Acta* **31**, 297 (1948).
- A. W. Nolle, Methods for measuring dynamic mechanical properties of rubber-like materials. *J. Applied Phys.* **19**, 753 (1948).
- A. W. Nolle, Comment on "A method of measuring dynamic mechanical properties of rubber-like materials". *J. Applied Phys.* **20**, 227 (1949).
- A. W. Nolle and S. C. Mowry, Measurement of ultrasonic bulk wave propagation in high polymers. *J. Acoust. Soc. Am.* **20**, 432 (1948).
- P. A. Rebinder and N. A. Semenenko, Use of the penetrating-cone method for the characterization of mechanical properties of viscoplastic bodies. *Doklady Akad. Nauk SSSR* **64**, 835 (1949).
- R. S. Rivlin, The hydrodynamics of non-Newtonian fluids. I. *Proc. Roy. Soc. (London)* **A 193**, 260 (1948).
- R. S. Rivlin, Large elastic deformations of isotropic materials. I. Fundamental concepts; II. Some uniqueness theorems for pure homogeneous deformation. *Philosophical Trans. Roy. Soc. (London)* **A 240**, 459 (1948).
- T. F. Protzman, Transition temperatures of methyl methacrylate polymers at ultrasonic frequencies. *J. Applied Phys.* **20**, 627 (1949).
- T. Sakai, Theory of rubber elasticity. *J. Phys.-Math. Soc. Japan* **17**, 226 (1943).
- T. Sakai and A. Ishihara, The statistical theory of rubber-like elasticity. *J. Colloid Sci.* **4**, 71 (1949).
- G. Schay, The relaxation of rubber. *Bul. soc. chim. Belges* **57**, 170 (1948).
- W. Scheele, Elasticity and flow in high polymers. *Z. Naturforschung* **4a**, 433 (1949).
- W. C. Schneider and C. J. Burton, Determination of the elastic constants of solids by ultrasonic methods. *J. Applied Phys.* **20**, 48 (1949).
- G. W. Scott Blair, Rheology of plastic solids. *Proc. Univ. Durham Phil. Soc.* **10**, 468 (1948).
- G. W. Scott Blair and J. E. Caffyn, Further experimental evidence for the theory of quasi-properties. *Nature* **162**, 368 (1948).
- G. W. Scott Blair and J. E. Caffyn, An application of the theory of quasi-properties to the treatment of anomalous strain-stress relations. *Phil. Mag.* **40**, 80 (1949).
- G. W. Scott Blair, B. C. Veinoglou and J. E. Caffyn, Limitations of the Newtonian time scale in relation to nonequilibrium rheological states and a theory of quasi-properties. *Proc. Roy. Soc. (London)* **A 189**, 69 (1947).
- V. L. Simril, Internal plasticization. The effect of chemical structure. *J. Polymer Sci.* **2**, 142 (1947).
- L. R. G. Treloar, The elasticity of a network of long-chain molecules. III. *Trans. Faraday Soc.* **42**, 83 (1946).
- L. R. G. Treloar, The photoelastic properties of rubber. I. Theory of the optical properties of strained rubber. *Trans. Faraday Soc.* **43**, 277 (1947).

- L. R. G. Treloar, Stresses and birefringence in rubber subjected to general homogeneous strain. *Proc. Phys. Soc. (London)* **60**, 135 (1948).
- W. C. Wake, The theory of rate processes and the viscosity of long-chain compounds. *Trans. Faraday Soc.* **43**, 708 (1947).
- A. Weissler, Ultrasonic investigation of molecular properties of liquids. III. Linear polymethylsiloxanes. *J. Am. Chem. Soc.* **71**, 93 (1949).
- R. S. Witte, B. A. Mrowca, and E. Guth, Propagation of audio-frequency sound in high polymers. *J. Applied Phys.* **20**, 481 (1949).
- L. M. Yang, Kinetic theory of diffusion in gases and liquids. II. General kinetic theory of liquid mixtures. *Proc. Roy. Soc. (London)* **A 198**, 471 (1949).

104.4 Dielectric and Related Investigations

- T. Akahira and M. Kamazawa, Effect of relative humidity on the dielectric-loss angle and surface resistivity of insulating materials at high frequencies. *Bul. Inst. Phys. Chem. Research* **20**, 589 (1941).
- A. E. W. Austen, Dielectric properties of homogeneous materials at high electric stress. *J. Inst. Elec. Engrs. (London)* **92 I**, 373 (1945).
- A. E. W. Austen and H. Pelzer, Electric strength of paraffins of some high polymers. *J. Inst. Elec. Engrs. (London)* **93 I**, 25 (1946).
- E. B. Baker, A. J. Barry, and M. J. Hunter, Dielectric constants of dimethylsiloxane polymers. *Ind. Eng. Chem.* **38**, 1117 (1946).
- R. Charbonnière, Static dielectric constant of polyvinyl chloride. *Compt. rend.* **226**, 909 (1948).
- R. Charbonnière, Curves for dielectric losses in polyvinyl chlorides of increasing viscosity. *Compt. rend.* **229**, 46 (1949).
- S. K. Chatterjee, Effect of moisture content on the dielectric properties of some solid insulating materials at ultra-high frequencies. *Indian J. Phys.* **22**, 259 (1948).
- S. K. Chatterjee and M. Rajeswari, Dielectric constants of some solid insulating materials at ultrashort waves. *Indian J. Phys.* **22**, 180 (1948).
- N. Chirkov, Surface conductance of solid dielectrics. *J. Phys. Chem. (USSR)* **21**, 1303 (1947).
- G. E. Crouch, Jr., Dielectric measurements of liquids at microwave frequencies. *J. Chem. Phys.* **16**, 364 (1948).
- M. A. Elliott, A. R. Jones, and L. B. Lockhart, Dielectric identity tests for plasticizers; polyvinyl chloride plastics type. *Anal. Chem.* **19**, 10 (1947).
- H. Fröhlich, Dielectric properties of dipolar solids. *Proc. Roy. Soc. (London)* **A 185**, 399 (1946).
- H. Fröhlich, The theory of dielectric breakdown in solids. *Proc. Roy. Soc. (London)* **A 188**, 521 (1947).
- R. Goldschmidt, Dielectric studies of polymeric liquids. *Schweiz. Arch. angew. Wiss. Tech.* **13**, 21 (1947).
- S. Kambara, Oil resistance of rubber. VIII. Relation between the oil resistance and polarity of various synthetic rubbers. *J. Soc. Chem. Ind. Japan* **45**, 1007 (1942); IX. Dipole moment of acrylonitrile. **47**, 518 (1944).
- R. Kawai, Dielectric properties of a thermoplastic resin. Dielectric absorption of a fusible phenolic resin at high frequencies and its interpretation by the complex or elasto-viscous relaxation times. *J. Inst. Elec. Engrs. Japan* **61**, 456 (1941).
- R. Kawai, Theoretical consideration on the dielectric absorption of fusible resin. *J. Inst. Elec. Engrs. Japan* **63**, 303 (1943).
- G. King, The effect of strongly-bonding agents on some polar polymers. *J. Colloid Sci.* **2**, 551 (1947).
- G. King and J. A. Medley, Direct-current conduction in swollen polar polymers. II. The influence of temperature and adsorbed salts on the direct current conductivity of polar polymer absorbate systems. *J. Colloid Sci.* **4**, 9 (1949).
- G. King and J. A. Medley, Effect of polar vapors on the direct-current conductance of keratin and nylon. *Nature* **160**, 438 (1947).
- P. P. Kobeko, G. P. Mikhailov, and Z. I. Novikova, Polymers. X. Dielectric losses in polar polymers. *J. Tech. Phys. (USSR)* **14**, 24 (1944).

- W. Kuhn, Relation between shape and dipole moment of chain molecules. *Helv. Chim. Acta* **31**, 1092 (1948).
- W. Kuhn, Dielectric relaxation of high polymers. I. *Helv. Chim. Acta* **31**, 1259 (1948).
- R. J. Meakins, Dielectric relaxation-times of solid solutions of aliphatic long-chain esters and ketones in paraffin wax and *n*-hexacasane. *Nature* **162**, 994 (1948).
- W. G. Oakes, Intrinsic electric strength of polythene. *Nature* **159**, 29 (1947).
- W. G. Oakes, The intrinsic electric strength of polythene and its variation with temperature. *J. Brit. Inst. Elec. Engrs.* **95**, Part I, 36 (1948).
- R. B. Richards, Dielectric properties of high polymers, a review. *Trans. Faraday Soc.* **42**, 194 (1946).
- A. Schallamach, Dielectric relaxation and viscosity of long-chain dipolar liquids. *Trans. Faraday Soc.* **42**, 495 (1946).
- A. Schallamach and P. Thirion, Dielectric loss in swollen rubber. *Trans. Faraday Soc.* **45**, 605 (1949).
- W. H. Surber, Jr., and G. E. Crouch, Jr., Dielectric measurement methods for solids at microwave frequencies. *J. Applied Phys.* **19**, 1130 (1948).
- A. Von Hippel and L. G. Wesson, Polystyrene plastics as high-frequency dielectrics. *Ind. Eng. Chem.* **38**, 1121 (1946).
- A. P. Votinov, P. P. Kobeko, and G. P. Mikhailov, Polymers. IX. Dielectric losses in nonpolar polymers. *J. Tech. Phys. (USSR)* **14**, 18 (1944).
- F. Würstlin, Dielectric data on the chain mobility of high-molecular substances. *Kolloid-Z.* **110**, 71 (1948).
- F. Würstlin, Dielectric investigation of solvation layer in plasticized polyvinyl chloride. *Kolloid-Z.* **113**, 18 (1949).

104.5 Optical Investigations

- E. J. Ambrose, A. Elliott, and R. B. Temple, The use of polarized infra-red radiation in the study of doubly oriented long-chain polymers. *Proc. Roy. Soc. (London) A* **199**, 183 (1949).
- K. E. Beu, X-ray diffraction patterns of stretched low-temperature polybutadiene using molybdenum, copper, and chromium radiations. *J. Polymer Sci.* **3**, 801 (1948).
- K. E. Beu, W. B. Reynolds, C. F. Fryling, and H. L. McMurphy, X-ray studies of low-temperature polybutadiene-styrene copolymers. *J. Polymer Sci.* **3**, 465 (1948).
- W. M. D. Bryant, Polythene fine structure. *J. Polymer Sci.* **2**, 547 (1947).
- C. W. Bunn, The study of high-polymer structure by X-ray diffraction methods. *J. Chem. Soc.* **1947**, 297.
- P. Debye and A. M. Bueche, Scattering by an inhomogeneous solid. *J. Applied Phys.* **20**, 518 (1949).
- H. L. Dinsmore and D. C. Smith, Analysis of natural and synthetic rubber by infrared spectroscopy. *Anal. Chem.* **20**, 11 (1948).
- A. Elliott, E. J. Ambrose, and R. B. Temple, Polarized infrared radiation as an aid to structural analysis of long-chain polymers. *J. Chem. Phys.* **16**, 877 (1948).
- A. Elliott, E. J. Ambrose, and R. B. Temple, Double orientation and infrared dichroism in polymers. *Nature* **163**, 567 (1949).
- J. E. Field, D. E. Woodford, and S. D. Gehman, Applications of infra-red methods in the structural examination of rubber. *J. Applied Phys.* **17**, 386 (1946).
- K. Fuchino, M. Tanaka, S. Yasui, and I. Sakurada, X-ray studies of synthetic high-molecular compounds. IX. X-rays of polystyrene and polyvinyl acetate at high temperatures. *Bul. Inst. Phys. Chem. Research (Tokyo)* **21**, 1084 (1942).
- K. Fuchino, S. Yasui, and I. Sakurada, X-ray studies of synthetic high-molecular compounds. V. Crystal structure of synthetic nylon fibers. *Bul. Inst. Phys. Chem. Research (Tokyo)* **21**, 1055 (1942); VI. Change in the crystal structure of nylon at high temperature. **21**, 1064; VII. Crystal structure of polyamide from azelaic acid and hexamethylenediamine. **21**, 1069; VIII. Heat-treatment of polyvinyl alcohol. **21**, 1077.
- C. S. Fuller, Mixed crystal formations in linear copolymers. *J. Am. Chem. Soc.* **70**, 421 (1948).

- J. M. Goppel, The degree of crystallinity in natural rubber. I. An improved method to determine the degree of crystallization in rubber. *Applied Sci. Research A1*, 3 (1947); II. The orientation of the rubber crystallites in stretched samples. *A1*, 18 (1947).
- A. Guinier, Determination of size and mutual arrangement of large molecules by means of small angle scattering. *Bul. soc. chim. Belges* 57, 286 (1948).
- F. A. Hamm and J. J. Comer, Replica studies of dyed nylon. *Anal. Chem.* 20, 861 (1948).
- R. R. Hampton, Infra-red analysis of low temperature polymers. *Anal. Chem.* 21, 923 (1949).
- E. E. Hanson and G. Halverson, X-ray diffraction study of some synthetic rubbers at low temperatures. *J. Am. Chem. Soc.* 70, 779 (1948).
- E. J. Hart and A. W. Meyer, Infra-red studies of 1,2- and *trans* 1,4- structures of polybutadiene and butadiene-styrene copolymers polymerized at various temperatures. *J. Am. Chem. Soc.* 71, 1980 (1949).
- E. A. Hauser and D. S. Le Beau, The effect of temperature and molecular-weight distribution on the morphology of natural and synthetic high polymers. *J. Phys. & Colloid Chem.* 52, 27 (1948).
- S. W. Hawkins and R. B. Richards, Light transmission and the formation and decay of spherulites in polythene. *J. Polymer Sci.* 4, 515 (1949).
- E. F. G. Herington and J. I. Jones, Ultraviolet absorption spectra of some copolymers containing acenaphthylene, and of related compounds. *J. Polymer Sci.* 4, 725 (1949).
- P. H. Hermans, The degree of crystallinity in native and regenerated cellulose fibers based on X-ray analysis. *Bul. soc. chim. Belges* 57, 123 (1948).
- P. H. Hermans, Degree of lateral order in various rayons as deduced from X-ray measurements. *J. Polymer Sci.* 4, 145 (1949).
- P. H. Hermans and A. Weidinger, Quantitative X-ray investigations on the crystallinity of cellulose fibers. A background analysis. *J. Applied Phys.* 19, 491 (1948).
- P. H. Hermans and A. Weidinger, X-ray studies on the crystallinity of cellulose. *J. Polymer Sci.* 4, 135 (1949).
- P. H. Hermans and A. Weidinger, Estimation of crystallinity of some polymers from X-ray intensity measurements. *J. Polymer Sci.* 4, 709 (1949).
- A. N. J. Heyn, Small-angle scattering of X-rays and micellar structure in cellulose fibers. *J. Am. Chem. Soc.* 71, 1873 (1949).
- G. A. Jeffrey, The structure of polyisoprenes. I. The crystal structure of geranylamine hydrochloride. *Proc. Roy. Soc. (London) A* 183, 388 (1945).
- A. Katchalsky and H. Wechsler, Determination of catalyst fragments in polymers by absorption in the ultraviolet. *J. Polymer Sci.* 1, 299 (1946).
- W. Kaye, An aluminum-beryllium alloy for substrate and replica preparations in electron microscopy. *J. Applied Phys.* 20, 1209 (1949).
- L. Kellner, Vibrations of an infinitely long chain of CH_2 -groups and the infra-red spectrum of polythene. *Nature* 163, 877 (1949).
- R. H. Kelsey and E. E. Hanson, A method for preparing rubber latex specimens for the electron microscope. *J. Applied Phys.* 17, 675 (1946).
- S. F. Kern, Technique of electron microscope investigation of fiber surfaces. *J. Polymer Sci.* 1, 259 (1946).
- G. W. King, R. M. Hainer, and H. O. McMahon, Infra-red absorption spectra of some polymers at liquid-helium temperatures. *J. Applied Phys.* 20, 559 (1949).
- O. Kratky, G. Porod, and A. Sekora, An X-ray investigation of the coiling of chain molecules in solution. *Monatsh.* 78, 295 (1948).
- O. Kratky and G. Porod, Diffuse small angle scattering of X-rays in colloid systems. *J. Colloid Sci.* 4, 35 (1949).
- J. Kruse, Measurement of carbon black in rubber by the microscope. *Kolloid-Z.* 110, 125 (1948).
- R. Kubo, Statistical theory of linear polymers. III. Double refraction. *J. Phys. Soc. Japan* 2, 84 (1947).
- R. Lagemann, Magnetic rotatory power of liquid polymers. *J. Polymer Sci.* 3, 663 (1948).
- H. A. Laitinen, F. A. Miller, and T. D. Parks, Ultraviolet absorption spectra of substituted vinyl aromatic monomers and polymers. *J. Am. Chem. Soc.* 69, 2707 (1947).

- J. Lecomte, J. J. Leendertse, and H. I. Waterman, The application of the infra-red absorption spectra to the study of polymerization products of hydrocarbons. *Bul. soc. chim. France* 1948, 253.
- C. Legrand, Precise measurements of the crystalline parameters of cellulose and its derivatives. *Bul. soc. chim. Belges* 57, 113 (1948).
- B. V. Lukin and V. I. Kasatochkin, X-ray investigation of the crystallization of vulcanized rubber on stretching. *J. Tech. Phys. (USSR)* 16, 1383 (1946).
- E. J. Meehan, Spectrophotometric determination of the styrene content of butadiene-styrene copolymers. *J. Polymer Sci.* 1, 175 (1946).
- E. J. Meehan, T. D. Parks, and H. A. Laitinen, Comparison of ultraviolet absorption and chlorine analysis methods for composition of butadiene-*p*-chlorostyrene copolymers. *J. Polymer Sci.* 1, 247 (1946).
- S. Okajima and T. Iwamoto, Refractive index of cellulose film. IV. Refractive indexes of nitrocellulose film and nitrated ramie; V. The type of change in refractive indexes by the plastic elongation of regenerated fiber and the effect thereon of varying the degree of swelling. *J. Soc. Chem. Ind. Japan* 44, 848 (1941).
- T. Petitpas, The empty structure of dinitrocellulose. *Compt. rend.* 227, 728 (1948).
- G. B. M. Sutherland and A. V. Jones, Use of polarized radiation in infrared analysis. *Nature* 160, 567 (1947).
- H. W. Thompson, The study of macromolecules by infrared spectroscopy. *J. Chem. Soc. (London)* 1947, 289.
- L. R. G. Treloar, Stress-optical properties of rubber. *Nature* 159, 231 (1947).
- L. R. G. Treloar, The photoelastic properties of rubber. II. Double refraction and crystallization in stretched vulcanized rubber. *Trans. Faraday Soc.* 43, 284 (1947).
- W. B. Treumann and F. T. Wall, Determination of 1,2 addition in polymers and copolymers of butadiene. *Anal. Chem.* 21, 1161 (1949).
- R. A. Saunders and D. C. Smith, Infra-red spectra and structure of Hevea and Gutta-elastomers. *J. Applied Phys.* 20, 953 (1949).
- T. Simanouti, The normal vibration of polyatomic molecules as calculated by Urey-Bradley field. II. Vibrations of polythene, ethane, and their deuterium compounds. *J. Chem. Phys.* 17, 734 (1949).
- T. Simanouti and S. Mizushima, The constant frequency Raman lines of N-paraffins. *J. Chem. Phys.* 17, 1102 (1949).
- J. A. Victoreen, The calculation of X-ray mass absorption coefficients. *J. Applied Phys.* 20, 1141 (1949).
- L. G. Wallner, The influence of crystallite length on the X-ray diffraction pattern of polyamides. *Monatsh.* 79, 86 (1948).
- E. Wantuch, J. G. Rohrbaugh, J. P. Cooley, J. H. Greig, and J. Schmoys, Transmission properties of materials in the millimeter wave region. *J. Applied Phys.* 19, 1092 (1948).
- C. D. West, Structure-optical studies. I. X-ray diffraction by addition compounds of halogens with hydrophilic organic polymers. *J. Chem. Phys.* 15, 689 (1947); II. Aqueous dispersions of polyvinyl borate-iodine and its heat of formation; 17, 219 (1949).
- R. H. Wiley, Relation between specific refractivity of polymers and atomic structure of polymer unit. *Ind. Eng. Chem.* 38, 959 (1946).
- R. H. Wiley, Refractometric determination of second-order transition in polyvinyl acetate. *J. Polymer Sci.* 2, 10 (1947).
- R. H. Wiley and G. M. Brauer, Refractometric determination of second-order transition temperatures in polymers. II. Some acrylic, vinyl halide, and styrene polymers. *J. Polymer Sci.* 3, 455 (1948); III. Acrylates and methacrylates. 3, 647; IV. Butadiene-acrylonitrile copolymers. 3, 704.
- R. H. Wiley and G. M. Brauer, Specific refractivity-temperature data for polyvinyl acetate and polybutyl acrylate. *J. Polymer Sci.* 4, 351 (1949); Errata. 4, 538.
- R. H. Wiley and P. H. Hobson, Determination of refractive index of polymers. *Anal. Chem.* 20, 520 (1948).
- R. C. Williams and R. W. G. Wyckoff, Applications of metallic shadow-casting to microscopy. *J. Applied Phys.* 17, 23 (1946).
- N. Wright and M. G. Hunter, Organosilicon polymers. III. Infrared spectra of the methyl polysiloxanes. *J. Am. Chem. Soc.* 69, 803 (1947).

- L. A. Wood and L. W. Tilton, Refractive index of natural rubber for different wavelengths. *J. Research NBS* **43**, 57 (1949).
- C. W. Young, P. C. Servais, C. C. Currie, and M. J. Hunter, Organic polymers. IV. Infrared studies on cyclic disubstituted siloxanes. *J. Am. Chem. Soc.* **70**, 3758 (1948).

200. SOLUTIONS AND GELS

201. THERMODYNAMICS OF SOLUTIONS

- G. C. Benson and R. L. McIntosh, Surface pressure-area measurements for films of polyvinyl acetate polymers spread on water. *J. Colloid Sci.* **3**, 323 (1948).
- E. Calvet, Calorimetric study of the gelatinization of nitrocelluloses by acetic esters. *Compt. rend.* **217**, 482 (1943); *Ann. faculte sci. Marseille* **16**, 161 (1944).
- E. Calvet, Specific volumes of nitrocellulose-acetone systems, heats of dilution, and the semi-ideal state of acetone solutions of nitrocellulose. *Bul. soc. chim. France* **12**, 553 (1945).
- A. Dobry, Note on incompatibility and separation of macromolecules. *J. chim. phys.* **44**, 16 (1947).
- A. Dobry, Precipitating power as a function of molecular weight. *J. Polymer Sci.* **2**, 623 (1947).
- A. Dobry, The incompatibility of macromolecules in an aqueous solution. *Bul. soc. chim. Belges* **57**, 280 (1948).
- A. Dobry and F. Boyer-Kawenoki, Phase separation in polymer solution. *J. Polymer Sci.* **2**, 90 (1947).
- P. Doty, M. Brownstein, and W. Schlener, Some thermodynamic properties of polystyrene solutions. *J. Phys. & Colloid Chem.* **53**, 213 (1949).
- J. Duclaux, Steric hindrance in macromolecular solutions. *J. Polymer Sci.* **2**, 626 (1947).
- P. J. Flory, Statistical mechanics of dilute polymer solutions. *J. Chem. Phys.* **17**, 1347 (1949).
- P. J. Flory, Thermodynamics of polymer solutions. *Record Chem. Progress* **10**, 153 (1949).
- H. Funahashi, Copolymer of vinyl chloride and vinyl acetate. I. Copolymerization and the solubility of copolymer in solvents. *J. Soc. Chem. Ind. Japan* **47**, 792 (1944).
- G. Gavoret and M. Magat, Thermodynamics of high polymer solutions. III. Precipitability of GR-S. *J. chim. phys.* **46**, 355 (1949).
- G. Gee, Some thermodynamic properties of high polymers and their molecular interpretations. *Quart. Revs. (London)* **1**, 265 (1947).
- S. A. Glikman and L. A. Root, Dilatometric characterization of energy effects on dilution of high polymer solutions. *Doklady Akad. Nauk SSSR* **65**, 701 (1949).
- J. J. Hermans, Thermodynamic properties of macromolecules in solution. *Nederland. Tijdschr. Natuurk.* **12**, 210 (1946).
- W. Heukelom, A method for the accurate calculations of some thermodynamic properties of nonpolar or moderately polar substances, based on Van Laar's theory. *Rec. trav. chim.* **68**, 661 (1949).
- J. H. Hildebrand, Entropy of solution of molecules of different size. *J. Chem. Phys.* **15**, 225 (1947).
- K. Hoshino, Synthetic polyamides. V. Precipitability and melt viscosity. *Bul. Chem. Soc. Japan* **19**, 171 (1944).
- M. L. Huggins, Theory of the thermodynamic properties of solutions of chain molecules. *J. chim. phys.* **44**, 9 (1947).
- M. L. Huggins, The effect of size, shape, and flexibility of the solute molecules on the properties of colloidal solutions. *J. Phys. & Colloid Chem.* **52**, 243 (1947).
- E. Jenckel, Vapor pressure and partial miscibility of high polymer solutions. *Z. Naturforsch.* **3a**, 290 (1948).
- W. Kuhn, The shape of chain molecules in good and bad solvents. *Helv. Chim. Acta* **32**, 735 (1949).

- M. Magat, Thermodynamics of high polymer solutions. II. Solubility of high polymers. *J. chim. phys.* **46**, 344 (1949).
- A. R. Miller, Solutions of high polymers. *Australian J. Sci.* **10**, 6 (Aug., 1947).
- A. R. Miller, High-polymer molecules in solution. *Endeavor* **8**, 140 (1949).
- A. R. Miller, Entropy of dilution of a polymer-solvent system. *Nature* **163**, 839 (1949).
- A. Münster, Some properties of chain molecules in solution. II. Properties of linear molecules in solution. *Z. Naturforsch.* **1**, 311 (1946); III. Solvation of chain molecules (Theory of solutions of high polymers. IV.); **2a**, 284 (1947).
- A. Münster, Theory of solution for high polymeric substances. III. Certain properties of linear molecules in solution. 2. Membrane equilibria. *Z. Naturforsch.* **2a**, 272 (1947).
- A. Münster, Thermodynamics and statistics of high molecular solutions. *Kolloid-Z.* **110**, 58 (1948).
- A. Münster, Principles and results of the statistical theory of macromolecular solutions. *Makromol. Chem.* **2**, 227 (1948).
- A. Münster, Thermodynamics and statistics of solutions of materials of high molecular weight. II. *Kolloid-Z.* **111**, 190 (1948).
- A. Münster, Theory of solution for high polymeric substances. V. Certain properties of linear molecules in solution. 4. Statistical theory of solvation. *Kolloid-Z.* **110**, 200 (1948).
- M. S. Muthana and H. Mark, Solubility of polyethylene in xylene. *J. Polymer Sci.* **4**, 527 (1949); *Rec. trav. chim.* **68**, 756 (1949).
- W. J. C. Orr, Statistical treatment of polymer solutions at infinite dilution. *Trans. Faraday Soc.* **43**, 12 (1947).
- A. G. Pasynskii, Solvation of nonelectrolytes and compressibility of their solutions. *J. Phys. Chem. (USSR)* **20**, 981 (1946).
- A. G. Pasynskii, Compressibility of colloidal solutions and the solvation of colloids. *Acta Physicochim. URSS* **22**, 263 (1947).
- P. O. Powers, Solubility of polystyrene in hydrocarbons. *Ind. Eng. Chem.* **41**, 126 (1949).
- P. O. Powers, Solubility of polystyrene. *Ind. Eng. Chem.* **41**, 2213 (1949).
- G. V. Schulz, Statistical derivation of the limit law for dilute solutions with varying molar volumes. *Z. Naturforsch.* **2a**, 27 (1947).
- G. V. Schulz, Statistical theory of macromolecular solutions. II. Entropy of mixing and osmotic pressure of solutions of long rigid particles. *Z. Naturforsch.* **2a**, 348 (1947); III. Entropy of mixing and osmotic pressure in solutions of flexible rod-shaped particles; **2a**, 411 (1947).
- R. L. Scott, Thermodynamics of high polymer solutions. IV. Phase equilibria in the ternary system: polymer 1- liquid 1- liquid 2. *J. Chem. Phys.* **17**, 268 (1949); V. Phase equilibria in the ternary system: polymer 1—polymer 2—solvent. **17**, 279 (1949).
- H. M. Spurlin, Polymer solutions. *J. Polymer Sci.* **3**, 714 (1948).
- A. J. Staverman, The use of the van Laar-Hildebrand equation in high polymer chemistry. *Bul. soc. chim. Belges* **57**, 177 (1948).
- H. Tompa, Thermodynamics of the system benzene-biphenyl. *J. Chem. Phys.* **16**, 292 (1948).
- J. Winter, The long-range attractions between macromolecules in a liquid medium. *Compt. rend.* **226**, 704 (1948).
- B. H. Zimm, Application of the methods of molecular distribution to solutions of large molecules. *J. Chem. Phys.* **14**, 164 (1946).

202. MOLECULAR WEIGHT AND SIZE

202.1 Fractionation; Molecular Weight Distribution

- G. Beall, Determination of distribution of molecular size in a sample of cellulose. *J. Polymer Sci.* **4**, 483 (1949).
- G. Beauvalet and P. Clément, Average molecular weights of high polymers. Methods of calculation and representation of polymolecularity. *Bul. soc. chim. France*, 1949, DI-14.

- R. F. Boyer, Molecular-weight-distribution data on high polymers. Graphical representation. *Ind. Eng. Chem. Anal. Ed.* **18**, 342 (1946).
- Ö. Bryde and A. Banderet, The different averages of molecular size in a polydisperse sample. *Acta Chem. Scand.* **3**, 554 (1949).
- F. H. Burstall, G. R. Davies, R. P. Linstead, and R. A. Wells, Inorganic chromatography on cellulose. *Nature* **163**, 64 (1949).
- S. Claesson, Adsorption analysis of high-molecular substances. *Arkiv Kemi, Mineral. Geol.* **26 A**, No. 24 (1949).
- L. H. Cragg and H. Hammerschlag, The fractionation of high-polymeric substances. *Chem. Rev.* **39**, 79 (1946).
- S. N. Danilov, The relation of nitrocellulose of differing degrees of heterogeneity to volatile and non-volatile solvents. *Akad. Nauk SSSR* **1**, 36 (1943).
- V. Desreux, Fractional extraction of polymers. *Bul. soc. chim. Belges* **57**, 416 (1948).
- V. Desreux, Systematic fractional extraction of polymers. *Rec. trav. chim.* **68**, 789 (1949).
- A. Dobry, Coacervation. IV. Study of a binary system. *J. chim. phys.* **42**, 92 (1945); V. Fractionation of macromolecules by coacervation. **42**, 109 (1945).
- V. Garten and W. Becker, Size and shape of Buna molecules. *Makromol. Chem.* **3**, 78 (1949).
- G. S. Hartley and B. A. Toms, Thermal migration of macromolecules. *Nature* **158**, 451 (1946).
- G. Herdan, Use of statistical inequalities in polymer research. *Research (London)* **2**, 235 (1949).
- G. Herdan, Estimation of polymer distribution on the basis of differences between the average molecular weights of different order. *Nature* **163**, 139 (1949).
- P. Herrent and G. Jnoff, Potentiometric titration of viscose. *J. Polymer Sci.* **3**, 487 (1948); **II**, **3**, 834 (1948).
- P. Herrent and R. Govaerts, Polydispersion of cellulose samples from wood pulp. *J. Polymer Sci.* **4**, 289 (1949).
- L. Jacqué, A. Jaussellin, and F. Millot, Fractionation of the phenoplastic resins by selective solution. *Compt. rend.* **227**, 1031 (1948).
- K. Kanamaru and F. Oyama, Relation between the distribution of polymerization degrees and the mechanical properties of chainlike polymers. I. Fractionation of nylon. *J. Soc. Chem. Ind. Japan* **46**, 1273 (1943).
- V. V. Korshak, Change of the molecular weight of high polymers in the process of chemical destruction. *Doklady Akad. Nauk SSSR* **64**, 525 (1949).
- A. E. Korvezee, P. M. Heertjes, W. J. Hessels, and K. M. Knip, Molecular-weight determination by freezing-point depression. *Chem. Weekblad* **42**, 363 (1946).
- R. Kronig, The statistical analysis of macromolecular mixtures, particularly with the aid of magnetic measurements. *Bul. soc. chim. Belges* **57**, 182 (1948).
- E. Kunst and M. Magat, Molecular weight distribution in polymers formed in solution. *Compt. rend.* **225**, 499 (1947).
- I. Landler, Chromatographic fractionation of some synthetic elastomers. *Compt. rend* **225**, 629 (1947).
- D. B. MacLean, M. Morton, and R. V. V. Nicholls, Compositional heterogeneity of copolymers. Effect on viscosity and fractionation studies. *Ind. Eng. Chem.* **41**, 1622 (1949).
- H. Mark, Purity and identity of polymers. *Anal. Chem.* **20**, 104 (1948).
- W. E. Mochel, J. B. Nichols, and C. J. Mighton, The structure of Neoprene. I. The molecular-weight distribution of Neoprene, type GN. *J. Am. Chem. Soc.* **70**, 2185 (1948).
- W. E. Mochel and J. H. Peterson, The structure of Neoprene. II. Determination of end groups by means of radio-sulfur. *J. Am. Chem. Soc.* **71**, 1426 (1949).
- W. E. Mochel and J. B. Nichols, The structure of Neoprene. III. The molecular weight distribution of Neoprene, type CG. *J. Am. Chem. Soc.* **71**, 3435 (1949).

- D. R. Morey and J. W. Tambllyn, Experimental studies on the fractionation of high polymers. *J. Phys. Chem.* **50**, 12 (1946).
- D. R. Morey and J. W. Tambllyn, The fractional precipitation of molecular-weight species from high polymers. Theories of the process and some experimental evidence. *J. Phys. & Colloid Chem.* **51**, 721 (1947).
- G. W. Nederbragt and J. J. de Jong, The separation of long-chain and compact molecules by adsorption. *Rec. trav. chim.* **65**, 831 (1946).
- F. Pass, Kinetics of indene polymerization. II. Distribution function in thermal polymers of indenenes. *J. Polymer Sci.* **3**, 327 (1948).
- S. R. Rafikov, V. V. Korshak, and G. N. Chelnokova, High molecular compounds. XVIII. The average molecular weight of polymer homologs. *Bul. acad. sci. URSS, Classe sci. chim.* **1949**, 90.
- J. L. Rosenberg and C. O. Beckmann, The use of metal membranes for fractionating high polymers. *J. Colloid Sci.* **3**, 483 (1948).
- G. V. Schulz, Determination of molecular weights of macromolecular compounds. XVI. The distribution function and the average polymerization degree of polymolecular substances. *J. makromol. Chem.* **1**, 131 (1944).
- D. W. Scott, Equilibria between linear and cyclic polymers in methyl-polysiloxanes. *J. Am. Chem. Soc.* **68**, 2294 (1946).
- W. H. Stockmayer, Solubility of heterogeneous polymers. *J. Chem. Phys.* **17**, 588 (1949).
- J. Tanaka, Molecular distribution of rubber. II. Natural rubber. *J. Soc. Chem. Ind. Japan* **47**, 686 (1944); III. Perbunam. **47**, 687 (1944); VII. Reproducibility of the molecular distribution curve, **47**, 692 (1944).
- G. B. Taylor, The distribution of the molecular weight of nylon as determined by fractionation in a phenol-water system. *J. Am. Chem. Soc.* **69**, 638 (1947).
- F. T. Wall and L. F. Beste, Properties of polymers as functions of conversion. III. Molecular weights of bottle polymerized GR-S. *J. Am. Chem. Soc.* **69**, 1761 (1947).
- J. E. Waltz and G. B. Taylor, Determination of the molecular weight of nylon. *Anal. Chem.* **19**, 448 (1947).
- H. A. Wannow and F. Thormann, The determination of chain length distribution in cellulose. *Kolloid-Z.* **112**, 94 (1949).
- H. Werbin, An improved method of precipitating and drying vinyl copolymers. *Science* **107**, 400 (1948).

202.2 Osmotic Pressure

- M. Abribat and J. Pouradier, Determination of the molecular weight of high polymers by a tensiometer with a roughened strip. *Compt. rend.* **227**, 1101 (1948).
- M. F. Bechtold, Molecular weight methods. *J. Polymer Sci.* **4**, 401 (1949).
- E. Blanchard Castillo, Macromolecular compounds; determination of their molecular weights. *Ion* **7**, 310 (1947).
- G. V. Browning and J. D. Ferry, Thermodynamic studies of polyvinyl acetate solutions in the dilute and moderately concentrated range. *J. Chem. Phys.* **17**, 1107 (1949).
- A. Dobry, A simplified method for the measurement of osmotic pressure of synthetic macromolecules. *J. chim. phys.* **42**, 114 (1945).
- P. Doty and E. Mishuck, The temperature dependence of the osmotic pressure of polyvinyl chloride solutions. *J. Am. Chem. Soc.* **69**, 1631 (1947).
- P. Doty, H. Wagner, and S. Singer, The association of polymer molecules in dilute solution. *J. Phys. & Colloid Chem.* **51**, 32 (1947).
- G. Emschwiller, General equations of osmotic pressure. Osmotic pressure of colloidal solutions. *J. chim. phys.* **43**, 36 (1946).
- B. Enoksson, An improved osmotic balance. *J. Polymer Sci.* **3**, 314 (1948).
- R. M. Fuoss, Physical chemistry of polymers. *Am. Scientist* **36**, 258 (1948).
- K. B. Goldblum, Notes on dynamic osmometry. *J. Phys. & Colloid Chem.* **51**, 474 (1947).
- J. T. Hutton, A review of some recent developments in the study of macromolecules. *Australian Chem. Inst. J. & Proc.* **14**, 151 (1947).
- I. Jullander, Nitrocellulose. Construction of an osmotic balance. *Arkiv. Kemi Mineral. Geol.* **21 A**, 142 (1945).

- E. Kunst and M. Magat, Effect of chain branching on the osmotic pressure of high polymers. *Compt. rend.* **227**, 902 (1948).
- C. R. Masson and H. W. Melville, Osmometry of high polymer solutions. I. Osmometer and membranes. *J. Polymer Sci.* **4**, 323 (1949); II. Osmotic measurements using bacterial cellulose membranes. **4**, 337 (1949).
- R. McIntosh and J. A. Morrison, Molecular weight of some polyvinyl acetates. *Can. J. Research* **24 B**, 192 (1946).
- M. S. Muthana and H. Mark, Number-average molecular weight of acetaldehyde polymer. *J. Polymer Sci.* **4**, 91 (1949).
- M. S. Muthana and H. Mark, Osmotic measurements of isomeric polyvinyl isobutyl ethers. *J. Polymer Sci.* **4**, 531 (1949).
- H. Portzehl, Techniques of colloidal measurements. I. The measurement of very small osmotic pressures. *Makromol. Chem.* **3**, 132 (1949).
- R. E. Robertson, R. McIntosh, and W. E. Grummitt, The influence of membrane preparation on the osmotic pressure of polyvinyl acetate in acetone. *Can. J. Research* **24 B**, 150 (1946).
- G. D. Sands and B. L. Johnson, Complete apparatus for determination of osmotic molecular weights. *Ind. Eng. Chem. Anal. Ed.* **19**, 261 (1947).
- G. V. Schulz, Determination of molecular weights of macromolecular compounds. XVIII. Comparison of the molecular weights of cellulose nitrates derived from osmotic and ultracentrifugal measurements. *J. makromol. Chem.* **1**, 146 (1944).
- D. W. Scott, Osmotic-pressure measurements with polydimethyl-silicone fractions. *J. Am. Chem. Soc.* **68**, 1877 (1946).
- A. F. Sirianni, L. M. Wise, and R. L. McIntosh, Osmotic-pressure measurement and the instability of high polymers. *Can. J. Research* **25 B**, 301 (1947).
- T. Svedberg, The cellulose molecule. Physical-chemical studies. *J. Phys. & Colloid Chem.* **51**, 1 (1947).
- I. I. Zhukov, I. Y. Poddubnyi, and A. V. Lebedev, Physico-chemical study of solutions of synthetic rubber. I. Osmotic pressure of sodium-butadiene rubber solutions. *Kolloid. Zhur.* **10**, 423 (1948).

202.3 Sedimentation and Diffusion

- W. J. Archibald, A demonstration of some new methods of determining molecular weights from the data of the ultracentrifuge. *J. Phys. & Colloid Chem.* **51**, 1204 (1947).
- M. Banderet, Some applications of the ultracentrifuge to the studies of salts of acid cellulose glycolate. *J. chim. phys.* **44**, 52 (1947).
- J. W. Beams, J. L. Young, III, and J. W. Moore, The production of high centrifugal fields. *J. Applied Phys.* **17**, 886 (1946).
- M. C. Brooks and R. M. Badger, A semi-micro diffusion method for the characterization of high-polymer fractions. *J. Phys. & Colloid Chem.* **52**, 1390 (1948).
- E. Calvet, Interferometric studies of diffusion and sedimentation in liquids. Application to high polymers. *J. chim. phys.* **44**, 47 (1947).
- C. A. Coulson, J. T. Cox, A. G. Ogston, and J. St. L. Philpot, Rapid method for determining diffusion constants in solution. *Proc. Roy. Soc. (London)* **A 192**, 382 (1948).
- B. Enoksson, Influence of solvent movement on sedimentation. *Nature* **161**, 934 (1948).
- H. Fritzemeyer and J. J. Hermans, Thermogravitational diffusion of polymers. Preliminary report. *Bul. soc. chim. Belges* **57**, 136 (1948).
- R. Gilbert, Translational diffusion coefficient. *J. chim. phys.* **44**, 37 (1947).
- G. Goldfinger, The mechanism of reinforcement. II. *J. Polymer Sci.* **1**, 58 (1946).
- N. Gralén, The number average diffusion constants. *Acta Chem. Scand.* **1**, 388 (1948).
- J. Hengstenberg and G. V. Schulz, The molecular weight of polystyrenes as determined by the ultracentrifuge and osmotic pressure. *Makromol. Chem.* **2**, 5 (1948).
- J. J. Hermans, The sedimentation velocity of long-chain macromolecules. *Rec. trav. chim.* **63**, 219 (1944).

- J. J. Hermans, Sedimentation and diffusion of cellulose molecules. *J. Polymer Sci.* **1**, 233 (1946).
- I. Jullander, Recent ultracentrifugal investigations on cellulose and cellulose derivatives. *J. Polymer Sci.* **2**, 329 (1947).
- I. Jullander, Concentration dependence of sedimentation constant for nitro-cellulose. *J. Polymer Sci.* **3**, 631 (1948).
- G. Kegeles, A new optical method for observing sedimentation equilibrium. *J. Am. Chem. Soc.* **69**, 1302 (1947).
- G. Kegeles and L. J. Gosting, The theory of an interference method for the study of diffusion. *J. Am. Chem. Soc.* **69**, 2516 (1947).
- P. O. Kinell, Determination of polydispersity from ultracentrifugal sedimentation. *Acta Chem. Scand.* **1**, 335 (1947).
- P. O. Kinell, The distribution of sizes of particles in some polymeric methyl methacrylates. *Acta Chem. Scand.* **1**, 832 (1947).
- P. O. Kinell, Molecular-weight determinations. *Svensk Kem. Tid.* **61**, 19 (1949).
- W. Kuhn and H. Kuhn, Diffusion, sedimentation, and viscosity of solutions of branched-chain molecules. *Helv. Chim. Acta* **30**, 1233 (1947).
- E. R. Lang, Q. Van Winkle, and W. G. France, Electrophoresis in an ultracentrifugal field. *J. Colloid Sci.* **2**, 315 (1947).
- H. Mosimann and R. Signer, Influence of hydrostatic pressure on sedimentation velocity in the ultracentrifuge. *Helv. Chim. Acta* **27**, 1123 (1944).
- L. Nicolas and E. Calvet, Perfection of the interferometric method of measuring vertical diffusion and sedimentation in liquids. *Compt. rend.* **228**, 559 (1949).
- A. G. Pasoyokoy and T. V. Gatavskaja, Molecular weight and polydispersity of rubber by diffusion measurements. *Nature* **157**, 518 (1946).
- B. G. Rånby, Examination of cellulose and cellulose derivatives in the ultracentrifuge. *Norsk. Skogsind.* **1**, 295 (1947).
- J. Riseman and J. G. Kirkwood, Rotatory diffusion constants of flexible molecules. *J. Chem. Phys.* **17**, 442 (1949).
- H. Sihtola and T. Svedberg, A new method to determine the degree of solvation of macromolecules. *Acta Chem. Scand.* **2**, 474 (1948).
- S. Singer, Molecular weight averages obtained from sedimentation velocity and diffusion measurements. *J. Polymer Sci.* **1**, 445 (1946).
- S. J. Singer, Effect of centrifugal field on resistance to motion of threadlike molecules in solution. *J. Polymer Sci.* **2**, 290 (1947).
- S. J. Singer and H. Mark, On the structure of cellulose acetate molecules in acetone solution. *J. Applied Phys.* **19**, 97 (1948).
- V. I. Sokolov, Approximate method of supercentrifuge-sedimentation. *Zavodskaya Lab.* **13**, 590 (1947).
- T. Svedberg, Molecular sedimentation in the ultracentrifuge. *Endeavour* **6**, 89 (1947).
- T. Svedberg, Investigations of sedimentation, diffusion, and osmotic pressure of macromolecules in solution. *Anales fis. y quím. (Madrid)* **44B**, 111 (1949).
- M. Wales, Sedimentation equilibria of polydisperse non-ideal solutes. I. Theory. *J. Phys. & Colloid Chem.* **52**, 235 (1948).
- M. Wales, J. W. Williams, J. O. Thompson, and R. H. Ewart, Sedimentation equilibria of polydisperse non-ideal solutes. *J. Phys. & Colloid Chem.* **52**, 983 (1948).

202.4 Viscosity

- T. Alfrey, Jr., The influence of solvent composition on the specific viscosities of polymer solutions. *J. Colloid Sci.* **2**, 99 (1947).
- L. E. Amborski and G. Goldfinger, Mechanism of reinforcement. III. Viscosity of carbon black suspensions in GR-S solutions. *Rec. trav. chim.* **68**, 733 (1949).
- R. H. Anderson and D. H. Wheeler, Polyamide resins from dilinoleic acid and ethylenediamine. Molecular weight-viscosity relationships. *J. Am. Chem. Soc.* **70**, 760 (1948).
- A. L. Back, Relation between gel content, plasticity, and dilute solution viscosity of elastomers. *Ind. Eng. Chem.* **39**, 1339 (1947).
- W. J. Badgley and H. Mark, Viscosity-molecular weight relationship for cellulose acetate. *J. Phys. & Colloid Chem.* **51**, 58 (1947).

- A. J. Barry, Viscometric investigation of dimethyl-siloxane polymers. *J. Applied Phys.* **17**, 1020 (1946).
- J. H. Baxendale, S. Bywater, and M. G. Evans, Relation between molecular weight and intrinsic viscosity for polymethyl methacrylate. *J. Polymer Sci.* **1**, 237 (1946).
- J. H. Baxendale, S. Bywater, and M. G. Evans, Molecular-weight distributions in polymethyl methacrylates. *Trans. Faraday Soc.* **42**, 675 (1946).
- F. W. Billmeyer, Jr., Methods for estimating intrinsic viscosity. *J. Polymer Sci.* **4**, 83 (1949).
- F. Breazeale, A suggested new method of determining molecular weight distribution. *J. Polymer Sci.* **3**, 141 (1948).
- H. C. Brinkman, A calculation of the viscosity and the sedimentation constant for solutions of large-chain molecules taking into account the hampered flow of the solvent through these molecules. *Physica* **13**, 447 (1947).
- H. C. Brinkman, Problems of fluid flow through swarms of particles and through macromolecules in solution. *Research (London)* **2**, 190 (1949).
- J. E. Caffyn, A correction in viscometry due to varying hydrostatic head. *Proc. Phys. Soc. (London)* **61**, 367 (1948).
- W. C. Carter, R. L. Scott, and M. Magat, The viscosity-molecular weight relation of natural rubber. *J. Am. Chem. Soc.* **68**, 1480 (1946).
- Y. Conseiller, The viscosity of macromolecular solutions. *Compt. rend.* **224**, 828 (1947).
- L. H. Cragg, The terminology of intrinsic viscosity and related functions. *J. Colloid Sci.* **1**, 465 (1946).
- L. H. Cragg, T. M. Rogers, and D. A. Henderson, The evaluation of the intrinsic viscosity (as intrinsic flow time) of GR-S in benzene. *Can. J. Research* **25 B**, 333 (1947).
- L. H. Cragg and T. M. Rogers, The effect of temperature and mixed-solvent composition on the intrinsic viscosity of GR-S. *Can. J. Research* **26 B**, 230 (1948).
- W. E. Davis, The effect of molecular weight distribution on the reduced viscosity-concentration coefficient. *J. Am. Chem. Soc.* **69**, 1453 (1947).
- W. E. Davis and J. H. Elliott, Present status of the intrinsic viscosity determination. *J. Colloid Sci.* **4**, 313 (1949).
- P. Debye, Intrinsic viscosity of polymer solutions. *J. Chem. Phys.* **14**, 636 (1946).
- P. Debye and A. M. Bueche, Intrinsic viscosity, diffusion, and sedimentation rate of polymers in solution. *J. Chem. Phys.* **16**, 573 (1948).
- H. Deuel and H. Neukom, Stretching of dissolved chain molecules by the introduction of side groups. *J. Polymer Sci.* **4**, 759 (1949).
- K. Dialer and W. Stabentheiner, Relation between molecular weight and viscosity in polyvinyl acetates. *Makromol. Chem.* **2**, 271 (1948).
- P. Doty and H. Mark, Size and shape of macromolecules in solution. *Ind. Eng. Chem.* **38**, 682 (1946).
- J. Duclaux, The meaning of dilution in macromolecular solutions. *Compt. rend.* **223**, 836 (1946).
- F. Eirich and J. Riseman, Some remarks on the first interaction coefficient of the viscosity-concentration equation. *J. Polymer Sci.* **4**, 417 (1949).
- H. C. Evans and D. W. Young, Polymers and viscosity index. *Ind. Eng. Chem.* **39**, 1676 (1947).
- T. G. Fox, Jr. and P. J. Flory, Viscosity-molecular weight and viscosity-temperature relationships for polystyrene and polyisobutylene. *J. Am. Chem. Soc.* **70**, 2384 (1948).
- T. G. Fox, Jr., and P. J. Flory, Intrinsic viscosity-molecular weight relationships for polyisobutylene. *J. Phys. & Colloid Chem.* **53**, 197 (1949).
- A. I. Goldberg, W. P. Hohenstein, and H. Mark, Intrinsic viscosity-molecular weight relationship for polystyrene. *J. Polymer Sci.* **2**, 503 (1947).
- R. Govaerts and G. Smet, Determination of intrinsic viscosity of linear polymers in concentrated solution. *J. Polymer Sci.* **2**, 612 (1947).
- D. A. Henderson and N. R. Legge, Further developments for the determination of the intrinsic viscosity of high polymers. *Can. J. Research* **27 B**, 666 (1949).
- A. K. Holliday, Method for the determination of viscosity at low rates of shear. *Trans. Faraday Soc.* **43**, 630 (1947).

- B. L. Johnson and R. D. Wolfangel, Viscosity-molecular weight relation for polybutadiene. Effect of polymerization temperature. *Ind. Eng. Chem.* **41**, 1580 (1949).
- K. Katsumasa, Viscosity of solutions and the shape of solute particles. I. Former viscosity formulas and the shape of solute particles. II. Coefficients of the new viscosity formula. *J. Soc. Chem. Ind. Japan* **46**, 954 (1943); III, IV, V, VI, Shape of particles of natural and synthetic high polymers in solution. VII. Comparison of the new viscosity formula with some experimental formulas. VIII. Summary. **46**, 1283 (1943); IX. Theory of viscosity formula. **47**, 653 (1944); X. Various theories on the form of natural chain molecules; **47**, 654 (1944).
- T. Kimishima and S. Mujama, Change in viscosity of rubber solutions in pure nitrogen. *J. Soc. Chem. Ind. Japan* **49**, 10 (1946).
- J. G. Kirkwood, The statistical-mechanical theory of irreversible processes in solutions of flexible macromolecules. *Rec. trav. chim.* **68**, 649 (1949).
- J. G. Kirkwood and J. Riseman, Intrinsic viscosities and diffusion constants of flexible macromolecules in solution. *J. Chem. Phys.* **16**, 565 (1948).
- H. A. Kramers, The behavior of macromolecules in inhomogeneous flow. *J. Chem. Phys.* **14**, 415 (1946).
- J. G. Kreible and J. C. Whitewell, The viscosity of Newtonian pseudoplastic and dilatant liquids; use in the measurement of the D.P. of high polymers. *Textile Research J.* **19**, 253 (1949).
- W. Kuhn, The shape of chain molecules in solution. *Experientia* **3**, 315 (1947).
- W. Kuhn and H. Kuhn, The importance of restricted free rotation for the viscosity and streaming double refraction of solutions of thread-like molecules. I. *Helv. Chem. Acta* **28**, 1533 (1945); II. **29**, 71 (1946).
- W. Kuhn and H. Kuhn, Rigidity of chain molecules and its determination from viscosity and flow birefringence in dilute solutions. *J. Colloid Chem.* **3**, 11 (1948). *Rev. inst. franç. pétrole et Ann. combustibles liquides* **3**, 207 (1948).
- W. Kuhn and H. Kuhn, Immobilization of solvent in randomly coiled chain molecules. *J. Chem. Phys.* **16**, 838 (1948).
- W. Kuhn, O. Künzle, and A. Katchalsky, The behavior of multivalent chain molecules in solution. *Helv. Chim. Acta* **31**, 1994 (1948).
- E. Kuss and H. A. Stuart, The specific viscosities of solutions of disc-like molecules and their temperature dependence. *Z. Naturforsch.* **3a**, 204 (1948).
- E. D. Kunst, Dimensions and intrinsic viscosity of coiled chain molecules in solution. *Nature* **164**, 535 (1949).
- J. A. Morrison, J. M. Holmes, and R. McIntosh, Instability of solutions of high polymers. *Can. J. Research* **24 B**, 179 (1946).
- S. Newman, J. Riseman, and F. Eirich, The shape of macromolecules in solution and the interrelationships of their hydrodynamic parameters. *Rec. trav. chim.* **68**, 921 (1949).
- T. Noguchi, Highly polymerized regenerated celluloses. I. Measurement of the polymerization degree of cellulose. *J. Soc. Chem. Ind. Japan* **44**, 692 (1941).
- A. V. Pamfilov, A. A. Morogov, and M. A. Rabkin, Viscosity of solutions of nitrocellulose and cellulose. VII. *J. Applied Chem. (USSR)* **19**, 914 (1946).
- W. Philippoff, The viscosity of colloids. *Z. Naturforsch.* **3b**, 151 (1948).
- J. L. Riley, The Baker-Philippoff equation for cellulose acetate solutions. *J. Polymer Sci.* **1**, 434 (1946).
- R. S. Rivlin, The normal-stress coefficient in solutions of macromolecules. *Trans. Faraday Soc.* **45**, 739 (1949).
- J. V. Robinson, The viscosity of suspensions of spheres. *J. Phys. & Colloid Chem.* **53**, 1042 (1949).
- T. M. Rogers, D. A. Henderson, and L. H. Cragg, A note on the variation with temperature of the intrinsic viscosity of GR-S in benzene. *Can. J. Research* **25 B**, 351 (1947).
- C. Sadron, A method of interpretation of the properties of chain molecules in very dilute solution. *J. chim. phys.* **44**, 22 (1947).
- C. Sadron, The physical properties of solutions of macromolecules. *Actes soc. helv. sci. nat.* **128**, 43 (1948).

- C. Sadron, Relation of intrinsic viscosity of polymer solution to degree of polymerization and temperature. *J. Polymer Sci.* **3**, 812 (1948).
- I. Sakurada, J. Matsuda, S. Matsumoto, and T. Chiba, Estimation of the degree of polymerization from the viscosity of solutions of high molecular compounds. *J. Soc. Chem. Ind. Japan* **47**, 133 (1944).
- J. R. Schaefgen and P. J. Flory, Synthesis of multichain polymers and investigation of their viscosities. *J. Am. Chem. Soc.* **70**, 2709 (1948).
- G. V. Schulz, Relation between viscosity and the size and shape of polystyrene molecules. *Makromol. Chem.* **3**, 146 (1949).
- R. L. Scott, W. C. Carter, and M. Magat, Viscosity-molecular weight relations for various synthetic rubbers. *J. Am. Chem. Soc.* **71**, 220 (1949).
- R. Simha, Effect of concentration on the viscosity of dilute solutions. *J. Research NBS* **42**, 409 (1949) RP1981.
- R. Simha, Viscosity of solutions of macromolecules. *Record Chem. Progress* **10**, 157 (1949).
- R. S. Spencer, Determination of molecular weight distributions. *J. Polymer Sci.* **3**, 606 (1948).
- H. Staudinger and F. Berndt, The validity of the viscosity law for polyoxydecanoic acids. *Makromol. Chem.* **1**, 22 (1947).
- H. Staudinger and F. Berndt, Polyoxyundecanoic acids. *Makromol. Chem.* **1**, 36 (1947).
- H. Staudinger and H. Schnell, The validity of the viscosity law for polyaminocaproic acids. *Makromol. Chem.* **1**, 44 (1947).
- J. Tanaka, Molecular distribution of rubber. I. *J. Soc. Chem. Ind. Japan* **47**, 684 (1944).
- G. B. Taylor, The relation of the viscosity of nylon solutions in formic acid to molecular weight as determined by end-group measurements. *J. Am. Chem. Soc.* **69**, 635 (1947).
- S. Ushakov, R. K. Gavurina, and V. P. Chekhovskaya, Formylation of polyvinyl alcohol and the Staudinger constant K_m for polyvinyl formate. *Bul. acad. sci. URSS Classe sci. chim.* **1947**, 71.
- G. Valet, Viscosity of high polymers—theory and technique. *Congr. tecn. intern. ind. peintures et ind. assoc.* **1947**, 285.
- V. Vand, Viscosity of solutions and suspensions. I. Theory. *J. Phys. & Colloid Chem.* **52**, 277 (1948).
- R. H. Wagner, Intrinsic viscosities and molecular weights of polyvinyl acetates. *J. Polymer Sci.* **2**, 21 (1947).
- R. H. Wagner, Application of corrections in viscometry of high-polymer solutions. *Anal. Chem.* **20**, 155 (1948).
- R. H. Wagner and J. Russell, Capillary-tube viscometer. For routine measurements of dilute high-polymer solutions. *Anal. Chem.* **20**, 151 (1948).
- F. T. Wall, R. W. Powers, G. D. Sands, and G. S. Stent, Properties of polymers as functions of conversion. II. Intrinsic viscosities. *J. Am. Chem. Soc.* **69**, 904 (1947).
- R. W. Watson and N. H. Grace, The viscosity-molecular weight relation for poly-levo-2,3-butanediyl *o*-phthalate. *Can. J. Research* **26 B**, 783 (1948).
- S. G. Weissberg and R. Simha, Viscosities of solutions of cellulose acetate in solvent-precipitant mixtures. *J. Colloid Sci.* **2**, 305 (1947).
- J. N. Wilson, Intrinsic viscosity of linear polymers. *J. Chem. Phys.* **17**, 217 (1949).
- F. Zapf, The K_m -values for cellulose nitrate from wood and for cotton cellulose. *Makromol. Chem.* **3**, 164 (1949).
- I. I. Zhukov, I. Y. Poddubnyi, and A. V. Lebedev, Physicochemical studies of solutions of synthetic rubber. II. Molecular weight and intrinsic viscosity of sodium-butadiene rubber. *Kolloid Zhur.* **11**, 151 (1949).

202.5 Optical Measurements

- R. M. Badger and R. H. Blaker, The investigation of the properties of nitrocellulose molecules in solution by light scattering methods. II. Experimental results and interpretation. *J. Phys. & Colloid Chem.* **53**, 1056 (1949).
- W. O. Baker, Control of composition of synthetic rubber. *Bell Labs. Record* **25**, 447 (1947).

- J. Bardwell and C. Sivertz, The determination of particle size by light scattering. *Can. J. Research* **25 B**, 255 (1947).
- H. Benoit, An apparatus for measuring the Kerr effect by isolated electric impulses. *Compt. rend.* **228**, 1716 (1949).
- H. Benoit, A theory of the Kerr effect of a solution exposed to a rectangular electric impulse. *Compt. rend.* **229**, 30 (1949).
- R. H. Blaker, R. M. Badger, and T. S. Gilmann, The investigation of the properties of nitrocellulose molecules in solution by light scattering methods. *J. Phys. & Colloid Chem.* **53**, 794 (1949).
- A. Boutaric and P. Berthier, Interferential refractometry of colloidal solutions. *Compt. rend.* **228**, 1009 (1949).
- H. C. Brinkman and J. J. Hermans, Effect of nonhomogeneity of molecular weight on the scattering of light by high polymer solutions. *J. Chem. Phys.* **17**, 574 (1949).
- A. M. Bueche, Dimensions of coiling polymer molecules from viscosity and light scattering. *J. Am. Chem. Soc.* **71**, 1452 (1949).
- T. Bücher, The validity of the Rayleigh equation (molecular weight from the light scattering of linear colloids). *Biochim. et Biophys. Acta* **1**, 477 (1947).
- R. Cerf, Method of determination of optical constants of a macromolecule in solution. *Compt. rend.* **226**, 405 (1948).
- J. F. Coyle and G. Goldfinger, A turbidimeter for the measurement of the solubility of slightly soluble liquids. *Science* **107**, 453 (1948).
- P. Debye, Photoelectric instrument for light scattering measurements and a differential refractometer. *J. Applied Phys.* **17**, 392 (1946).
- P. Debye, Molecular-weight determination by light scattering. *J. Phys. & Colloid Chem.* **51**, 18 (1947).
- B. Dogadkin, I. Soboleva, and M. Arkhangel'skaya, Determination of the molecular weight of rubber and polystyrene by the methods of light scattering and osmometry. *Kolloid Zhur.* **11**, 143 (1949).
- P. Doty, Recent physical investigations of polymer molecules. *Chem. Weekblad* **43**, 422 (1947).
- P. Doty, Depolarization of light scattered from dilute macromolecular solutions. I. Theoretical discussion. *J. Polymer Sci.* **3**, 750 (1948).
- P. Doty and S. J. Stein, Depolarization of light scattered from dilute macromolecular solutions. II. Experimental results. *J. Polymer Sci.* **3**, 763 (1948).
- R. H. Ewart, C. P. Roe, P. Debye, and J. R. McCartney, Determination of polymeric molecular weights by light scattering in solvent-precipitant systems. *J. Chem. Phys.* **14**, 687 (1946).
- E. Frisman and V. N. Tsvetkov, Depolarization of light scattered by polystyrene. *Acta Physicochim. URSS* **21**, 188 (1946).
- E. Frisman and V. Tsvetkov, Depolarization of the light scattered by polymer solutions. *J. Exp. Theoret. Phys. (USSR)* **18**, 126 (1948).
- H. J. Hadow, H. Sheffer, and J. C. Hyde, Light-scattering apparatus and techniques for measuring molecular weights of high polymers. *Can. J. Research* **27 B**, 791 (1949).
- E. A. Hauser and D. S. Le Beau, Microscopic studies of lyogels. *Ind. Eng. Chem.* **38**, 335 (1946).
- E. A. Hauser and D. S. Le Beau, The morphology of lyogels. *J. Phys. & Colloid Chem.* **51**, 278 (1947).
- E. A. Hauser and D. S. Le Beau, Ultramicroscopy of lyogels. *Kolloid-Z.* **110**, 78 (1948).
- W. Heller, H. B. Kleven, and H. Oppenheimer, The determination of particle sizes from Tyndall spectra. *J. Chem. Phys.* **14**, 566 (1946).
- E. Kunst, Preferential adsorption and the diffusion of light by solutions of macromolecules in certain binary mixtures. *Compt. rend.* **227**, 837 (1948).
- V. K. La Mer and M. D. Barnes, A note on the symbols and definition involved in light-scattering equations. *J. Colloid Sci.* **2**, 361 (1947).
- W. W. Lepeschkin, Molecular weight determination of high molecular substances by the method of longitudinal scattering in turbid mediums. *Kolloid-Z.* **110**, 89 (1948).
- W. H. Markwood, The determination of molecular weight by light scattering. *J. Franklin Inst.* **244**, 92 (1947).

- G. Oster, Light scattering from polymerizing and coagulating systems. *J. Colloid Sci.* **2**, 291 (1947).
- A. Peterlin, Random coil model for chain molecules. *Proc. Acad. Sci. Ljubljana-Jugoslavija Math. Phys. Soc.* **3**, 77 (1947).
- G. Porod, The dependence of small-angle X-ray scattering on the shape and size of colloidal particles in dilute systems. IV. *Acta Phys. Austria.* **2**, 255 (1949).
- G. V. Schulz, Molecular weight determinations on macromolecular compounds. XXI. Determinations of the absolute molecular weight of macromolecular compounds by measurement of the intensity of the scattered light. *Z. physik. Chem.* **194**, 1 (1944); *Chem. Centr.* **1**, 688 (1947).
- G. V. Schulz and G. Harborth, The determination of molecular weight and size of chain molecules by light scattering. *Makromol. Chem.* **2**, 187 (1948).
- R. S. Stein and P. Doty, A light scattering investigation of cellulose acetate. *J. Am. Chem. Soc.* **68**, 159 (1946).
- H. A. Stuart, Physical methods for the determination of size and shape of chain molecules in solution. *Makromol. Chem.* **3**, 176 (1949).
- V. N. Tsvetkov and E. Frisman, The magnetic double refraction of polystyrene. *Acta Physicochim. URSS* **19**, 323 (1944).
- V. N. Tsvetkov and E. Frisman, Birefringence of polyisobutylene solutions under flow. *Acta Physicochim. URSS* **20**, 61 (1945).
- V. N. Tsvetkov and E. Frisman, The influence of solvents on the Maxwell dynamo-optical effect in polyisobutylene solutions. *Acta Physicochim. URSS* **20**, 363 (1945).
- V. N. Tsvetkov and E. Frisman, Depolarization of light scattered in solutions of rubber-like polymers. *Compt. rend. acad. sci. URSS* **47**, 550 (1945).
- V. N. Tsvetkov, A. Mindlina, and G. Makarov, Dynamic and acoustic birefringence of some liquids. *Acta Physicochim. URSS* **21**, 135 (1946).
- V. N. Tsvetkov and A. Petrova, Dynamic birefringence in solutions of polymers of divinyl and methyl methacrylate. *J. Phys. Chem. (USSR)* **23**, 368 (1949).
- M. Wales, The application of flow birefringence measurements to high polymer solutions. *J. Phys. & Colloid Chem.* **52**, 976 (1948).
- J. Waser, R. M. Badger, and V. Schomaker, Light scattering of high polymer solutions. *J. Chem. Phys.* **14**, 43 (1946).
- B. H. Zimm, The dependence of the scattering of light on angle and concentration in linear polymer solutions. *J. Phys. & Colloid Chem.* **52**, 260 (1948).
- B. H. Zimm, The scattering of light and the radial distribution function of high polymer solutions. *J. Chem. Phys.* **16**, 1093 (1948).
- B. H. Zimm, Apparatus and methods for measurement and interpretation of the angular variation of light scattering. Preliminary results on polystyrene solutions. *J. Chem. Phys.* **16**, 1099 (1948).

202.6 Polyelectrolytes

- W. S. Albrink and R. M. Fuoss, Electrical properties of synthetic membranes. *J. Gen. Physiol.* **32**, 453 (1949).
- F. Boyer-Kawenoki, Properties of some ionized macromolecular solutions. *Compt. rend.* **227**, 69 (1948).
- W. Broser, A new method for determining the molecular size of polyamides. *Makromol. Chem.* **2**, 248 (1948).
- G. I. Cathers and R. M. Fuoss, Polyelectrolytes. IV. Conductance of *n*-butyl bromide addition compounds of 4-vinylpyridine-styrene copolymers in nitro-methane-dioxane mixtures. *J. Polymer Sci.* **4**, 121 (1949).
- D. Edelson and R. M. Fuoss, Chain electrolytes. *J. Am. Chem. Soc.* **70**, 2832 (1948).
- R. M. Fuoss, Polyelectrolytes. *Science* **108**, 545 (1948).
- R. M. Fuoss, Viscosity function for polyelectrolytes. *J. Polymer Sci.* **3**, 603 (1948); *Errata.* **4**, 96 (1949).
- R. M. Fuoss, The physical chemistry of synthetic polyelectrolytes. *Record Chem. Progress* **10**, 169 (1949).

- R. M. Fuoss and G. I. Cathers, Polyelectrolytes. I. Picrates of 4-vinyl pyridine-styrene copolymers. *J. Polymer Sci.* **2**, 12 (1947); III. Viscosities of *n*-butyl bromide addition compounds of 4-vinylpyridine-styrene copolymers in nitromethane-dioxane mixtures. **4**, 97 (1949).
- R. M. Fuoss and U. P. Strauss, Polyelectrolytes. II. Poly-4-vinylpyridonium chloride and poly-4-vinyl-*N*-*n*-butylpyridonium bromide. *J. Polymer Sci.* **3**, 246 (1948).
- R. M. Fuoss and U. P. Strauss, Electrostatic interaction of polyelectrolytes and simple electrolytes. *J. Polymer Sci.* **3**, 602 (1948).
- R. M. Fuoss and U. P. Strauss, Viscosity of mixtures of polyelectrolytes and simple electrolytes. *Ann. N. Y. Acad. Sci.* **51**, 836 (1949).
- S. Guinard, F. Boyer-Kawenoki, A. Dobry, and T. Tonnelat, Configuration of macromolecular filaments ionized in solution. *Compt. rend.* **229**, 143 (1949).
- W. D. Harkins and H. Oppenheimer, Solubilization of polar-nonpolar substances in solutions of long-chain electrolytes. *J. Am. Chem. Soc.* **71**, 808 (1949).
- J. J. Hermans, Light-scattering by charged particles in electrolyte solutions. *Rec. trav. chim.* **68**, 859 (1949).
- J. J. Hermans and J. T. G. Overbeek, Theory of the electroviscous effect in polymer solutions. *Bul. soc. chim. Belges* **57**, 154 (1948).
- J. J. Hermans and J. T. G. Overbeek, The dimensions of charged long-chain molecules in solutions containing electrolytes. *Rec. trav. chim.* **67**, 761 (1948).
- I. Kagawa, High-molecular electrolytes. I. Some considerations of the electrolytic dissociation of high-molecular electrolytes. II. Electrolytic dissociation of glycolic acid cellulose ether. *J. Soc. Chem. Ind. Japan* **47**, 435 (1944).
- I. Kagawa and K. Tsumura, High molecular electrolytes. III. Characteristic ionization constant of high-molecular electrolyte. IV. Electro-viscosity effect in solutions of glycolic acid ether. *J. Soc. Chem. Ind. Japan* **47**, 574 (1944).
- A. Katchalsky and J. Gillis, Theory of the potentiometric titration of polymeric acid. *Rec. trav. chim.* **68**, 879 (1949).
- A. Katchalsky and P. Spitnik, Potentiometric titrations of polymethacrylic acid. *J. Polymer Sci.* **2**, 432 (1947); Errata; **2**, 487 (1947).
- W. Kern, The activity of sodium ions in aqueous solutions of the salts of polyvalent acids. *Makromol. Chem.* **2**, 279 (1948).
- W. Kuhn, O. Künzle, and A. Katchalsky, The behavior of polyvalent chain ions in solution. *Bul. soc. chim. Belges* **57**, 421 (1948).
- O. Künzle, The effect of moderate ion concentrations on the electrostatic energy of chain molecules in solution. *Rec. trav. chim.* **68**, 699 (1949).
- J. T. G. Overbeek, The dissociation and titration constants of polybasic acids. *Bul. soc. chim. Belges* **57**, 252 (1948).
- D. T. F. Pals and J. J. Hermans, Concentration dependence of the viscosity of sodium pectinate in solutions of NaCl. *J. Polymer Sci.* **3**, 897 (1948).
- R. Signer and T. Brechbühler, Electrophoretic study of a mixture of thymonucleic acid and cellulose methyl ether. *Bul. soc. chim. Belges* **57**, 163 (1948).
- U. P. Strauss and R. M. Fuoss, Polyelectrolytes. V. Osmotic pressure of poly-4-vinyl-*N*-*n*-butylpyridonium bromide in ethanol at 25°C. *J. Polymer Sci.* **4**, 457 (1949).
- F. T. Wall and E. H. DeButts, Jr., The ionization of polymeric electrolytes. *J. Chem. Phys.* **17**, 1330 (1949).

203. CONCENTRATED SOLUTIONS, GELS, FILMS

203.1 Sorption of and Swelling by Gases and Liquids

- G. J. Van Amerongen, The permeability of different rubbers to gases and its relation to diffusivity and solubility. *J. Applied Phys.* **17**, 972 (1946).
- G. J. Van Amerongen, Solubility, diffusion, and permeation of gases in gutta-percha. *J. Polymer Sci.* **2**, 382 (1947).
- W. W. Barkas, Sorption and swelling of cellulose under natural and imposed restraints. *Proc. Tech. Sect., Paper Makers' Assoc. Gt. Brit. & Ireland* **28**, 189 (1947).

- W. W. Barkas, Hysteresis in the swelling of gels. *Nature* **162**, 32 (1948).
- R. M. Barrer, The solubility of gases in elastomers. *Trans. Faraday Soc.* **43**, 3 (1947).
- R. M. Barrer and G. Skirrow, Transport and equilibrium phenomena in gas-elastomer systems. I. Kinetic phenomena. *J. Polymer Sci.* **3**, 549 (1948); II. Equilibrium phenomena. **3**, 564 (1948).
- E. C. Baughan, Absorption of organic vapors by thin films of polystyrene. *Trans. Faraday Soc.* **44**, 495 (1948).
- R. F. Boyer and R. S. Spencer, Some thermodynamic properties of slightly cross-linked styrene-divinylbenzene gels. *J. Polymer Sci.* **3**, 97 (1948).
- J. W. Breitenbach and H. P. Frank, The swelling equilibrium of polystyrene in binary liquid mixtures. *Monatsh.* **76**, 282 (1947).
- J. W. Breitenbach and H. P. Frank, Specific viscosity and swelling of polystyrene. *Monatsh.* **77**, 206 (1947).
- J. W. Breitenbach and H. P. Frank, Osmotic and swelling equilibria of polystyrene and entropy of swelling. *Monatsh.* **79**, 531 (1948).
- A. S. Buchanan and E. Heymann, Electrokinetic potential of cellulose and electrokinetic equations. *Trans. Faraday Soc.* **44**, 318 (1948).
- E. Calvet, Passage of gels to solution. The solution of polyvinylchlorides in tetrahydrofuran. *J. chim. phys.* **45**, 290 (1948).
- J. Calv  t, R. Dalbert, and J. Ch  din, Gelatinization phenomena: calorimetric study of the absorption of acetone by the Bakelites. *M  m. services chim.   tat* (Paris) **32**, 220 (1945).
- H. Campbell and P. Johnson, Interaction between cellulose nitrate in solution and inorganic salts. *J. Polymer Sci.* **3**, 735 (1948); Investigations on cellulose nitrate. II. Liquid and vapor phase adsorption of acetone; **4**, 247 (1949).
- A. S. Carpenter, Crystallinity in solid colloids. II. Solution and diffusion in high polymers. *Trans. Faraday Soc.* **43**, 529 (1947).
- A. B. D. Cassie, Multimolecular absorption. II. *Trans. Faraday Soc.* **43**, 615 (1947).
- N. L. Cotton and D. C. Thompson, Effect of carbon blacks on swelling of neoprene GRM-10 vulcanizates. *Ind. Eng. Chem.* **40**, 1523 (1948).
- P. Cl  ment, Solvation and swelling of cellulosic polymers. *Ann. chim.* **2**, 420 (1947).
- M. L. Corrin, E. L. Lind, A. Roginsky, and V. V. D. Harkins, Adsorption of long-chain electrolytes from aqueous solution on graphite of known area and polystyrene. *J. Colloid Sci.* **4**, 485 (1949).
- J. Crank and G. S. Park, Evaluation of the diffusion coefficient for chloroform in polystyrene from simple absorption experiments. *Trans. Faraday Soc.* **45**, 240 (1949).
- D. J. Crisp, Surface films of polymers. I. Films of the fluid type. *J. Colloid Sci.* **1**, 49 (1946); II. Films of the coherent and semicrystalline type; **1**, 161 (1946).
- J. F. H. Custers, Diffusion of water into a polymer. *J. Polymer Sci.* **2**, 301 (1947).
- J. A. Cutler and A. D. McLaren, Sorption of water vapor by proteins and polymers. III. *J. Polymer Sci.* **3**, 792 (1948).
- M. Dole, Statistical thermodynamics of the sorption of vapors by solids. *J. Chem. Phys.* **16**, 25 (1948).
- M. Dole, Statistical analysis of the sorption of vapors by high polymers. *J. Colloid Sci.* **3**, 411 (1948).
- M. Dole and A. D. McLaren, The free energy, heat, and entropy of sorption of water vapor by proteins and high polymers. *J. Am. Chem. Soc.* **69**, 651 (1947).
- P. M. Doty, On the diffusion of vapors through polymers. *J. Chem. Phys.* **14**, 244 (1946).
- P. Doty and H. S. Zable, Determination of polymer-liquid interaction by swelling measurements. *J. Polymer Sci.* **1**, 90 (1946).
- S. F  n  ant, Gelatinization of polyvinyl chloride. *M  m. services chim.   tat* (Paris) **32**, 346 (1945).
- R. F. Field, The formation of ionized water films on dielectrics under conditions of high humidity. *J. Applied Phys.* **17**, 318 (1946).

- W. F. Fowler, Jr., C. C. Unruh, P. A. McGee, and W. O. Kenyon, The solubility of cellulose in mixtures of nitrogen tetroxide with organic compounds. *J. Am. Chem. Soc.* **69**, 1636 (1947).
- A. Frey-Wyssling and K. Mühlethaler, Submicroscopic structure of cellulose gel. *J. Polymer Sci.* **1**, 172 (1946).
- G. Gee, Equilibrium properties of high-polymer solutions and gels. *J. Chem. Soc.* **1947**, 280.
- G. Gee and W. J. C. Orr, The interaction between rubber and liquids. VIII. A new examination of the thermodynamic properties of the system rubber-benzene. *Trans. Faraday Soc.* **42**, 507 (1946).
- C. Gurney, Thermodynamic relations for two phases containing two components in equilibrium under generalized stress. *Proc. Phys. Soc. (London)* **59**, 629 (1947).
- G. S. Hartley, Diffusion and swelling of high polymers. I. The swelling of a high polymer solid considered as a diffusion process. *Trans. Faraday Soc.* **42**, 6 (1946); III. Anisotropic swelling in oriented polymer film; **45**, 820 (1949).
- P. M. Hauser and A. D. McLaren, Permeation through and sorption of water vapor by high polymers. *Ind. Eng. Chem.* **40**, 112 (1948).
- P. S. H. Henry, The diffusion of moisture and heat through textiles. *Discussions Faraday Soc.* **1948**, 243.
- T. L. Hill, Statistical mechanics of multimolecular adsorption. III. Introductory treatment of horizontal interactions. Capillary condensation and hysteresis. *J. Chem. Phys.* **15**, 767 (1947).
- R. Houwink, Permeability of polymers by gases and liquids. *Verfkroniek* **20**, 172 (1947).
- R. Houwink, Interaction between polymers and fillers. *J. Polymer Sci.* **4**, 763 (1949).
- Y. Inoue, Solubility of cellulose derivatives. VIII. Solubility of cellulose acetate in mixed solvents containing chloroform. IX. Solubility of cellulose acetate in mixed solvents containing acetone. X. Solubility of cellulose acetate in mixed solvents containing alcohol. *J. Soc. Chem. Ind. Japan* **45**, 927 (1942).
- Y. Inoue and K. Nitami, Solubility of cellulose ethers. *J. Soc. Chem. Ind. Japan* **46**, 287 (1943).
- K. Kanamaru and Y. Kawada, Effect of heat on chain polymers. III. Effect of heat on polyvinylalcohol in salt solutions and syneresis series of ions. *J. Soc. Chem. Ind. Japan* **47**, 714 (1944); IV. Thermoelastic behavior of polyvinyl alcohol in saturated salt solutions and syneresis series of ions. **47**, 717 (1944).
- G. S. Kasbekar and S. M. Neale, The swelling of cellulose in aqueous solutions of certain acids and salts with measurements of the vapor pressures, densities, and viscosities of these solutions. *Trans. Faraday Soc.* **43**, 517 (1947).
- A. Katchalsky, Rapid swelling and deswelling of reversible gels of polymeric acids by ionization. *Experientia* **5**, 319 (1949).
- A. E. Korvezee and E. A. J. Mol, Diffusion of water vapor through high polymeric membranes. *J. Polymer Sci.* **2**, 371 (1947); Errata; **2**, 487 (1947).
- M. A. Kovacs, Diffusion and absorption of water in plastic materials. *J. chim. phys.* **45**, 258 (1948).
- H. Kuhn, Determination of gel structure from permeability measurements by the principle of hydrodynamical similarity. *Experientia* **2**, 64 (1946).
- W. Kuhn, Reversible extension and contraction with change in ionization of a network of multivalent filamentous molecules. *Experientia* **5**, 318 (1949).
- S. M. Lipatov, Thermodynamic properties of high polymers. *Compt. rend. acad. sci. URSS* **48**, 409 (1945).
- W. R. Moore, Swelling of nitrocellulose in binary mixtures. *Trans. Faraday Soc.* **43**, 543 (1947).
- H. Neukom, Gels of polyvinyl alcohol formed by secondary valences. *Helv. Chim. Acta* **32**, 1233 (1949).
- D. M. Newitt and K. E. Weale, Solution and diffusion of gases in polystyrene at high pressures. *J. Chem. Soc.* **1948**, 1541.
- S. Papkov, Structure of high-polymer gels. *J. Phys. Chem. (USSR)* **18**, 560 (1944).

- M. Prasad and D. Venkatesha, Scattering of light during the process of gel formation. *J. Colloid Sci.* **4**, 349 (1949).
- R. Prince and J. Seiberlich, Shrinkage phenomena on cellulose films. *J. Phys. Chem.* **50**, 222 (1946).
- R. B. Richards, The phase equilibria between a crystalline polymer and solvents. I. *Trans. Faraday Soc.* **42**, 10 (1946); II. **42**, 20 (1946).
- P. E. Rouse, Diffusion of vapors in films. *J. Am. Chem. Soc.* **69**, 1068 (1947).
- J. W. Rowen and R. Simha, Interaction of polymers and vapors. *J. Phys. & Colloid Chem.* **53**, 921 (1949).
- I. Sakurada and M. Taniguchi, Wettability of high-molecular substances by water. *J. Soc. Chem. Ind. Japan* **49**, 35 (1946).
- G. Salomon and G. J. Van Amerongen, Influence of structure on polymer-liquid interaction. I. Relative and absolute values of swelling equilibria. *J. Polymer Sci.* **2**, 355 (1947).
- G. Salomon, Influence of structure on polymer-liquid interaction. II. Influence of nitrile groups. *J. Polymer Sci.* **3**, 173 (1948); III. Swelling and mechanical properties of some partly crystallized polymers. **3**, 776 (1948).
- R. L. Scott and M. Magat, Thermodynamics of high polymer solutions. III. Swelling of cross-linked rubber. *J. Polymer Sci.* **4**, 555 (1949).
- R. Simha and J. W. Rowen, On the distribution of water in cellulose and other materials. *J. Am. Chem. Soc.* **70**, 1663 (1948).
- S. E. Smith, The sorption of water vapor by high polymers. *J. Am. Chem. Soc.* **69**, 646 (1947).
- A. J. Stamm and H. Tarkow, Wood, a limited-swelling gel. *J. Phys. & Colloid Chem.* **53**, 251 (1949).
- A. Tager and V. A. Kargin, The mechanism of swelling of rubberlike high-molecular substances. High-molecular isoparaffins and isooctane. *Kolloid Zhur.* **10**, 455 (1948).
- M. Taniguchi and M. Hosono, Moisture adsorption by cellulose acetate. *J. Soc. Chem. Ind. Japan* **46**, 1103 (1943).
- M. Taniguchi and M. Hosono, Solvate formation of high molecular substances in dry condition. I. Determination of liquid retained in the film of high molecular substance. II. Influence of various factors on solvate formation. III. Effect of the degree of solvation on the mechanical properties of the film. IV. Effect of solvation on the measurement of solubility and swelling of the film. *J. Soc. Chem. Ind. Japan* **46**, 924 (1943).
- D. Vermaas and J. J. Hermans, The swelling of cellulose xanthate gels in dilute salt solutions. *Rec. trav. chim.* **67**, 983 (1948).
- M. Wahba, Moisture relationships of cellulose. I. The heat of wetting in water and certain organic liquids. *J. Phys. & Colloid Chem.* **52**, 1197 (1948).
- F. L. Warburton, Some thermodynamic relations of rigid hygroscopic gels. *Proc. Phys. Soc. (London)* **58**, 585 (1946).
- M. Watano, Process of solution of high-molecular compounds. Effect of polar groups in solute and solvent. I, II. Solutions of cellulose nitrate in mixed solvents containing acetone. III. Solutions of cellulose nitrate in mixed solvents containing alcohol. IV. Solutions of cellulose acetate. V. Behavior of mixed solvents. *J. Soc. Chem. Ind. Japan* **47**, 265 (1944); VI. Factors controlling solubility. VII. Quantitative relations involving polar groups in solute and solvent; **47**, 440 (1944); VIII, IX, X. Relation between solvent composition, polar substitution in solute, polymerization degree, and solubility; **47**, 445 (1944).
- J. W. Westwater, Oxygen absorption by cast plastic films. *Ind. Eng. Chem.* **40**, 1494 (1948).
- S. N. Zhurkov and R. I. Lerman, Influence of the volume sorption of vapors on the solidification temperature of polymers. *Compt. rend. acad. sci. (URSS)* **47**, 106 (1945).
- S. N. Zhurkov, Molecular mechanism of the solidification of polymers. *Compt. rend. acad. sci. (URSS)* **47**, 475 (1945).
- S. N. Zhurkov, The effect of volume sorption on the mechanical properties of polymers. *Compt. rend. acad. sci. (URSS)* **49**, 198 (1945).

203.2 Rheological Properties

- F. T. Adler, W. M. Sawyer, and J. D. Ferry, Propagation of transverse waves in viscoelastic media. *J. Applied Phys.* **20**, 1036 (1949).
- Y. B. Aron and P. A. Rebinder, Structure development in sols of polyvinyl chloride resins under the influence of SiO_2 as active filler. *Compt. rend. acad. sci. (URSS)* **52**, 235 (1946).
- J. N. Ashworth and J. D. Ferry, Mechanical properties of substances of high molecular weight. V. Rigidities of polyisobutylene solutions in various solvents. *J. Am. Chem. Soc.* **71**, 622 (1949).
- J. J. Bikerman, Penetroviscometer for very viscous liquids. *J. Colloid Sci.* **3**, 75 (1948).
- Y. Conseiller, Rigidity of macromolecular solutions. *Compt. rend.* **224**, 1711 (1947).
- Y. Conseiller, Elastic recovery and relaxation of concentrated solutions of macromolecules. *Compt. rend.* **225**, 1007 (1947).
- L. H. Cragg, L. M. Faichney, and H. F. Olds, The concentrated solution viscosity of GR-S. Its variation (in benzene) with temperature and concentration. *Can. J. Research* **26 B**, 551 (1948).
- D. Fensom and J. H. Greenblatt, A rheological study of solutions of nitrocellulose. *Can. J. Research* **26 B**, 215 (1948).
- J. D. Ferry, Viscoelastic properties of polymer solution. *J. Research NBS* **41**, 53 (1948).
- J. D. Ferry, Mechanical properties of substances of high molecular weight. IV. Rigidities of gelatin gels; dependence on concentration, temperature, and molecular weight. *J. Am. Chem. Soc.* **70**, 2244 (1948).
- J. D. Ferry, W. M. Sawyer, and J. N. Ashworth, Behavior of concentrated polymer solutions under periodic stresses. *J. Polymer Sci.* **2**, 593 (1947).
- L. Finkelstein, Rheological properties of incendiary gels. *J. Phys. & Colloid Chem.* **52**, 1460 (1948).
- H. Fröhlich and R. Sack, Theory of the rheological properties of dispersions. *Proc. Roy. Soc. (London) A* **185**, 415 (1946).
- G. I. Fuks and N. G. Puchkov, Viscosity of polyisobutylene solutions in mineral oils. II. Temperature dependence of viscosity. *Kolloid Zhur.* **11**, 34 (1949).
- G. Gee and W. J. C. Orr, The interaction between rubber and liquids. IX. The elastic behavior of dry and swollen rubbers. *Trans. Faraday Soc.* **42**, 585 (1946).
- K. Goldsmith, Measurement of the elasto-plastic properties of gels. *Nature* **163**, 601 (1949).
- J. Guastalla, The study of polymers by means of measurements of surface properties. *J. chim. phys.* **43**, 181 (1946).
- G. S. Hattiangdi and S. S. Dharmatti, A new method for measuring the time of setting of gel-forming systems. *Current Sci. (India)* **14**, 300 (1945).
- J. J. Hermans, Deformation and swelling of polymer networks containing comparatively long chains. *Trans. Faraday Soc.* **43**, 591 (1947).
- P. H. Hermans, Deformation mechanism of cellulose gels. I. Present status of the problem. *J. Polymer Sci.* **1**, 389 (1946).
- P. H. Hermans, J. J. Hermans, D. Vermaas, and A. Weidinger, Deformation mechanism of cellulose gels. II. Course of crystallite orientation compared to that required by Kratky's theory. *J. Polymer Sci.* **1**, 393 (1946); III. Changes in orientation upon drying; **2**, 632 (1947); IV. General relationship between orientation of the crystalline and that of the amorphous portion; **3**, 1 (1948).
- P. H. Hermans and A. Weidinger, The transformation of cellulose II into cellulose IV. *J. Colloid Sci.* **1**, 495 (1946).
- H. G. Higgins and K. F. Plomley, Study of the rheological properties of rapidly thickening colloidal systems by means of the Stormer viscometer. *Nature* **163**, 22 (1949).
- T. Higuchi, H. M. Leeper, and D. S. Davis, Determination of tensile strength of natural rubber and GR-S. Effect of specimen size. *Anal. Chem.* **20**, 1029 (1948).
- V. A. Kargin, The relation of the physical properties of solutions of compounds of high molecular weight to temperature. *Akad. Nauk SSSR* **2**, 60 (1944).

- E. V. Kuvshinskii, Peculiarities in the flow of solutions of high-molecular compounds. *Akad. Nauk SSSR* **1**, 11 (1943).
- C. Legrand, Hydration of native cellulose. *Compt. rend.* **226**, 1983 (1948).
- C. Mack, A theory of anomalous viscosity and elasticity. *J. Colloid Sci.* **4**, 343 (1949).
- M. Mooney, A viscometer for measurements during thixotropic recovery; results with a compounded latex. *J. Colloid Sci.* **1**, 195 (1946).
- F. H. Müller, Thixotropic state of high molecular substances. *Kolloid-Z.* **112**, 1 (1949).
- S. Peter, Theory of structural viscosity. *Kolloid-Z.* **114**, 44 (1949).
- R. S. Rivlin, Normal stress coefficient in solutions of macromolecules. *Nature* **161**, 567 (1948).
- T. L. Smith, J. D. Ferry, and F. W. Schremp, Measurements of the mechanical properties of polymer solutions by electromagnetic transducers. *J. Applied Phys.* **20**, 144 (1949).
- S. Sönnerskog, Sol-gel transformations of water-soluble ethylated hydroxyethylcellulose. *Svensk. Paperstidn.* **48**, 413 (1945).
- R. S. Spencer and J. L. Williams, Concentrated solution viscosity of polystyrene. *J. Colloid Sci.* **2**, 117 (1947).
- H. M. Spurlin, A. F. Martin, and H. G. Tennent, Characterization of cellulose derivatives by solution properties: Plasticizers as solvents. *J. Polymer Sci.* **1**, 63 (1946).
- B. A. Toms, Detection of a wall effect in laminar flow of solutions of a linear polymer. *J. Colloid Sci.* **4**, 511 (1949).
- O. N. Trapeznikova, An optical method for studying processes taking place on extended polystyrene films and determination of the photoelastic constant within the temperature interval of 12° to 140°. *J. Phys. Chem. (USSR)* **22**, 395 (1948).
- V. Vand, Theory of viscosity of concentrated suspensions. *Nature* **155**, 364 (1945).
- J. R. Van Wazer and H. Goldberg, The measurement of elasticity in fluids of low viscosity. *J. Applied Phys.* **18**, 207 (1947).
- S. Y. Veiler and P. A. Rebinder, The elasto-plastic properties and the thixotropy of disperse systems. *Compt. rend. acad. sci. (URSS)* **49**, 345 (1945).
- A. Voet, Molecular interaction in high-polymer solutions. *J. Phys. & Colloid Chem.* **53**, 597 (1949).
- A. Wissler, The concentration function of viscosity in colloidal solutions. *Makromol. Chem.* **3**, 5 (1949).

203.3 Adhesion

- J. J. Bikerman, The fundamentals of tackiness and adhesion. *J. Colloid Sci.* **2**, 163 (1947).
- C. H. Hofrichter, Jr., and A. D. McLaren, Temperature dependence of the adhesion of high polymers to cellulose. *Ind. Eng. Chem.* **40**, 329 (1948).
- A. D. McLaren, Influence of physical properties on adhesion of high polymers to cellulose. *Paper Trade J.* **126**, 139 (May 27, 1948).
- A. D. McLaren, Adhesion of high polymers to cellulose. Influence of structure, polarity, and tack temperature. *J. Polymer Sci.* **3**, 652 (1948).
- A. D. McLaren and C. J. Seiler, Adhesion. III. Adhesion of polymers to cellulose and alumina. *J. Polymer Sci.* **4**, 63 (1949); *Errata.* **4**, 408 (1949).
- S. Moses, The nature of adhesion. *Ind. Eng. Chem.* **41**, 2338 (1949).
- S. Moses and R. K. Witt, Evaluation of adhesion by ultrasonic vibrations. *Ind. Eng. Chem.* **41**, 2334 (1949).
- C. J. Seiler and A. D. McLaren, Theories of adhesion as applied to the adhesive properties of high polymers. *ASTM Bul.* **155**, 50 (1948).
- K. Thinius, The adhesion between layers of different polymers. *Kunststoffe* **37**, 36 (1947).

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301. POLYMERIZATION

301.1 Bulk Polymerization

- H. E. Adams and P. O. Powers, Thermal polymerization of drying oils. *J. Applied Phys.* **17**, 325 (1946).
- A. N. Akopyan and R. S. Gyuli-Kevkhyan, Cuprene polymerization of acetylenic hydrocarbons. I. Cuprene from monovinylacetylene. *J. Gen. Chem. (USSR)* **17**, 1533 (1947).
- T. Alfrey, Jr., F. J. Honn, and H. Mark, Preparation, purification, and polymerization of diethyl silicon dichloride. *J. Polymer Sci.* **1**, 102 (1946).
- L. V. Anderson and J. V. Porter, Relation of glyceride oil composition to polymerization. *Ind. Eng. Chem.* **41**, 741 (1949).
- B. Atkinson, Mercury photosensitized reaction of tetrafluoroethylene. *Nature* **163**, 291 (1949).
- D. W. E. Axford, Studies in polymerization. IV. The velocity constants in the polymerization of *p*-methoystyrene. *Proc. Roy. Soc. (London) A* **197**, 374 (1949).
- G. B. Bachman and R. W. Finholt, Monomers and polymers. II. α -Methylstyrenes and the steric hindrance of orthosubstituents. *J. Am. Chem. Soc.* **70**, 622 (1948).
- G. B. Bachman and L. V. Heisey, Monomers and polymers. VI. The preparation of vinyl derivatives of five-atom heterocyclic rings. *J. Am. Chem. Soc.* **71**, 1985 (1949).
- K. S. Bagdasar'yan, Photopolymerization of vinyl compounds. II. Photopolymerization of methyl methacrylate. *J. Phys. Chem. (USSR)* **21**, 25 (1947).
- C. H. Bamford and M. J. S. Dewar, Studies in polymerization. III. The polymerization of methyl methacrylate. *Proc. Roy. Soc. (London) A* **197**, 356 (1949).
- B. F. Bechthold, Kinetics of condensation polymerization. *J. Polymer Sci.* **4**, 219 (1949).
- M. E. Bedwell, Magnetic studies on polymerization. I. Magnetic optical rotatory powers and diamagnetic susceptibilities of certain polymethyl methacrylates. *J. Chem. Soc.* **1947**, 1350.
- W. I. Bengough and R. G. W. Norrish, A new catalytic effect in vinyl polymerizations. *Nature* **163**, 325 (1949).
- J. C. Bevington and R. G. W. Norrish, The polymerization of acetaldehyde at low temperatures. *Proc. Roy. Soc. (London) A* **196**, 363 (1949).
- T. F. Bradley and R. W. Tess, Thermal polymerization of esters of drying oil acids. *Ind. Eng. Chem.* **41**, 310 (1949).
- J. W. Breitenbach and G. Bremer, Chain rupture by peroxide in the polymerization of styrene. *Monatsh.* **80**, 107 (1949).
- J. W. Breitenbach and H. Preussler, Influence of activated carbon on styrene polymerization. *J. Polymer Sci.* **4**, 751 (1949).
- J. W. Breitenbach, H. Preussler, and H. Karlinger, The growth of inhomogeneous polymers. *Monatsh.* **80**, 150 (1949).
- J. W. Breitenbach and W. Thury, The polymerization of liquid vinyl chloride. *Experientia* **3**, 281 (1947).
- R. B. Carlin and N. E. Shakespeare, The polymerization of *p*-chlorostyrene in the presence of polymethylacrylate. *J. Am. Chem. Soc.* **68**, 876 (1946).
- S. G. Cohen, Products of initiation, retardation, and inhibition of peroxide-induced polymerization of styrene. *J. Polymer Sci.* **2**, 511 (1947).
- S. G. Cohen and D. B. Sparrow, Action of regulators in polymerization of monomers containing allyl and methacrylate groups. *J. Polymer Sci.* **3**, 693 (1948).
- S. G. Cohen, B. E. Ostberg, D. B. Sparrow, and E. R. Blout, Light-induced polymerization of some monomers containing allyl and methacrylate groups. *J. Polymer Sci.* **3**, 264 (1948).
- W. Cooper, Radical reactivity in the initiation reaction of the polymerization of styrene. *Nature* **162**, 897 (1948).
- W. Cooper, Peroxide catalyzed vinyl polymerization. *Nature* **162**, 927 (1948).

- F. S. Dainton and G. B. B. M. Sutherland, Application of infrared analysis to elucidate the mechanism of the boron trifluoride catalyzed vapor phase polymerization of isobutene at room temperature. *J. Polymer Sci.* **4**, 37 (1949).
- M. J. S. Dewar and C. H. Bamford, Polymerization of methyl methacrylate. *Nature* **158**, 380 (1946).
- G. Dixon-Lewis, Studies in polymerization. V. The polymerization of vinyl acetate. *Proc. Roy. Soc. (London) A* **198**, 510 (1949).
- L. H. Donally, Molecular size distribution for equilibrium of linear condensation polymers. *J. Phys. & Colloid Chem.* **53**, 1187 (1949).
- K. C. Eberly and B. L. Johnson, Vapor phase polymerization of 1,3-butadiene with sodium. *J. Polymer Sci.* **3**, 283 (1948).
- A. F. V. Eriksson, The change in particle size distribution of polymethyl methacrylate during polymerization. *Acta Chem. Scand.* **3**, 1 (1949).
- A. G. Evans and G. W. Meadows, Polymerization of isobutene catalyzed by boron trifluoride. *J. Polymer Sci.* **4**, 359 (1949).
- A. G. Evans and M. Polanyi, Polymerization of isobutene by Friedel-Crafts catalysts. *J. Chem. Soc.* **1947**, 252.
- A. G. Evans and E. Tyrrell, Heats of polymerization of acrylic acid and derivatives. *J. Polymer Sci.* **2**, 387 (1947).
- P. J. Flory, Fundamental principles of condensation polymerization. *Chem. Rev.* **39**, 137 (1946).
- R. G. Flowers and H. F. Miller, Acenaphthylene and its polymerization products. *J. Am. Chem. Soc.* **69**, 1388 (1947).
- A. R. Gantmakher and S. S. Medvedev, Catalytic polymerization of unsaturated compounds. *J. Phys. Chem. (USSR)* **23**, 516 (1949).
- P. A. Giguère, A magnetic rotation study of polymerization of styrene. *J. Polymer Sci.* **2**, 296 (1947).
- L. Gindin, A. Abkin, and S. Medvedev, The mechanism of the simultaneous polymerization of butadiene with vinyl cyanide and 1-methylvinyl cyanide under the action of benzoyl peroxide. *J. Phys. Chem. (USSR)* **21**, 1269 (1947).
- G. Goldfinger and K. E. Lauterbach, Initial rate of polymerization of styrene. *J. Polymer Sci.* **3**, 145 (1948).
- W. Graham and C. A. Winkler, Kinetic studies on the formation of polybutadiene. *Can. J. Research* **26 B**, 564 (1948).
- R. A. Gregg and F. R. Mayo, Chain transfer in the polymerization of styrene. II. The reaction of styrene with carbon tetrachloride. *J. Am. Chem. Soc.* **70**, 2373 (1948).
- V. Gutmann, Kinetics of indene polymerization. III. The effect of molecular oxygen on the polymerization of indenenes, *J. Polymer Sci.* **3**, 336 (1948); IV. Polyindene peroxides, **3**, 518 (1948); VII. The acceleration of the indene polymerization by the oxypolymers of the indene, **3**, 642 (1948); VIII. The acceleration of the polymerization by oxygen, **3**, 646 (1948).
- F. Halla and W. Schützner, The kinetics of indene polymerization. VI. Polymerization activity of indene fractions. *J. Polymer Sci.* **3**, 535 (1948).
- P. H. Hermans and J. Van Eyk, Reaction of benzoyl peroxide with cyclohexane and cyclohexene. Contribution to the mechanism of the catalyzing action of peroxides in the polymerization of vinyl derivatives. *J. Polymer Sci.* **1**, 407 (1946).
- T. L. Jacobs and W. P. Tuttle, Jr., Acetylenic ethers. V. Polymerization of phenoxyacetylene. *J. Am. Chem. Soc.* **71**, 1313 (1949).
- E. Jenckel, H. Eckmans, and B. Rumbach, Polymerization kinetics of vinyl chloride. *Makromol. Chem.* **4**, 15 (1949).
- W. Kern and H. Kämmerer, The incorporation of peroxide catalysts into the molecules of methyl methacrylate, vinyl acetate, and methacrylic nitrile during polymerization. *Makromol. Chem.* **2**, 127 (1948).
- I. L. Knunyants, Z. A. Rogovin, Y. A. Rymashevskaya, and E. V. Khait, Polymerization of unstable cyclic compounds. I. The polymerization of caprolactam. *J. Gen. Chem. (USSR)* **17**, 987 (1947).
- C. Koningsberger and G. Salomon, Preparation and properties of rubberlike high polymers. I. Polymerization of dienes and vinyl compounds in bulk. *J. Polymer Sci.* **1**, 200 (1946). II. Polymerization of mixtures in bulk, **1**, 353 (1946).
- I. E. Leffler and M. J. Sienko, Styrene polymerization in a magnetic field. *J. Chem. Phys.* **17**, 215 (1949).

- H. S. Lilley and G. L. Foster, Interaction of styrene with magnesium perchlorate and other salts. *Nature* **160**, 131 (1947).
- M. H. Mackay and H. W. Melville, Rate coefficients in the polymerization of methyl methacrylate. I. *Trans. Faraday Soc.* **45**, 323 (1949).
- M. S. Matheson, E. E. Auer, E. B. Bevilacqua, and E. J. Hart, Rate constants in free radical polymerizations. I. Methyl methacrylate. *J. Am. Chem. Soc.* **71**, 497 (1949). II. Vinyl acetate, **71**, 2610 (1949).
- F. R. Mayo and R. A. Gregg, Effects of inhibitors on the polymerization of styrene. *J. Am. Chem. Soc.* **70**, 1284 (1948).
- F. R. Mayo, Chain transfer in the polymerization of styrene. IV. The effect of chain length on the reaction of styrene and carbon tetrachloride. *J. Am. Chem. Soc.* **70**, 3689 (1948).
- S. Medvedev and P. Tseitlin, Oxidation and polymerization of styrene. *J. Phys. Chem. (USSR)* **18**, 13 (1944).
- H. W. Melville and A. F. Bickel, Determination of the velocity coefficients for polymerization processes. The polymerization of butyl acrylate. *Trans. Faraday Soc.* **45**, 1049 (1949).
- H. W. Melville and R. F. Tuckett, The photochemical polymerization of vinyl acetate vapor. *J. Chem. Soc.* **1947**, 1201.
- H. W. Melville and R. F. Tuckett, Radical-sensitized polymerization of vinyl acetate vapor. *J. Chem. Soc.* **1947**, 1211.
- H. W. Melville and W. F. Watson, Inhibition and retardation in polymerization reactions. *Trans. Faraday Soc.* **44**, 886 (1948).
- J. W. Menary, A. R. Ubbelohde, and M. J. Wright, The propagation of reaction chains in the polymerization of styrene. *J. Chem. Soc.* **1948**, 2232.
- A. A. Morton and H. C. Wohlers, Polymerization. IV. The reaction of organosodium reagents with styrene and 1,1-diphenylethylene. *J. Am. Chem. Soc.* **69**, 167 (1947).
- A. A. Morton and R. L. Letsinger, Polymerization. V. The catalytic polymerization of butadiene by phenylsodium and amylpotassium. *J. Am. Chem. Soc.* **69**, 172 (1947).
- A. A. Morton, E. E. Magat, and R. L. Letsinger, Polymerization. VI. The alfin catalysts. *J. Am. Chem. Soc.* **69**, 950 (1947).
- A. A. Morton and M. E. T. Holden, Polymerization. VII. The structure of the alfin catalyst. *J. Am. Chem. Soc.* **69**, 1675 (1947).
- J. Murata, Effect of polymerization retardant on the polymer of chloroprene. *J. Soc. Chem. Ind. Japan* **47**, 343 (1944).
- K. Nozaki and P. D. Bartlett, Rate constants of the steps in addition polymerization. I. The induction period in the polymerization of vinyl acetate. *J. Am. Chem. Soc.* **68**, 2377 (1946).
- A. Y. Pavlushina and M. V. Polyakov, Effect of the surface on the polymerization of vinyl acetate. *Doklady Akad. Nauk SSSR* **63**, 297 (1948).
- H. F. Pfann, V. Z. Williams, and H. Mark, Mechanism of peroxide-initiated styrene polymerization. Infra-red absorption of some polymer samples. *J. Polymer Sci.* **1**, 14 (1946).
- P. H. Plesch, M. Polanyi, and H. A. Skinner, The low-temperature polymerization of isobutene by Friedel-Crafts catalysts. *J. Chem. Soc.* **1947**, 257.
- M. V. Polyakov, A. Y. Pavlushina, and T. P. Karnienko, Polymerization of vinyl acetate. *Doklady Akad. Nauk SSSR* **62**, 101 (1948).
- J. Prat, Polymerization of vinyl chloride, *Mém. services chim. état (Paris)* **32**, 319 (1945).
- C. C. Price and D. H. Reas, Mechanism of vinyl polymerizations. VIII. Introduction of foreign end groups. *J. Polymer Sci.* **1**, 44 (1946).
- L. E. Redington, Diacyl peroxides as polymerization initiators: Rate of polymerization of styrene in relation to rate of decomposition of four organic peroxides. *J. Polymer Sci.* **3**, 503 (1948).
- C. E. Rehberg and W. A. Faucette, Preparation and properties of monomeric and polymeric acrylic esters of ether-alcohols. *J. Org. Chem.* **14**, 1094 (1949).
- R. E. Robertson and L. Marion, The mechanism of sodium-initiated polymerization of diolefins. *Can. J. Research* **26 B**, 657 (1948).
- Z. A. Rogovin and L. A. Tsaplina, Polymerization of vinyl compounds in the presence of esters of nitric acid. *J. Applied Chem. (USSR)* **20**, 883 (1947).

- G. Salomon, B. B. S. T. Boonstra, S. Van Der Meer, and A. J. Ultee, Preparation and properties of rubberlike high polymers. VI. Polymerization and dimerization of isoprene. *J. Polymer Sci.* **4**, 203 (1949).
- H. Schmid and V. Gutmann, Kinetics of indene polymerization. I. Thermal polymerization of indenenes. *J. Polymer Sci.* **3**, 325 (1948).
- G. V. Schulz and G. Harborth, The mechanism of the explosive polymerization of methyl methacrylate. *Makromol. Chem.* **1**, 106 (1947).
- C. G. Swain and P. D. Bartlett, Rate constants of the steps in addition polymerization. II. Uses of the rotating-sector method on liquid vinyl acetate. *J. Am. Chem. Soc.* **68**, 2381 (1946).
- O. Tanaevsky, Measurement of the magnetic susceptibility during the polymerization of vinyl acetate. *Compt. rend.* **225**, 1069 (1947).
- A. D. F. Toy, Allyl esters of phosphonic acids. I. Preparation and polymerization of allyl and methallyl esters of some arylphosphonic acids. *J. Am. Chem. Soc.* **70**, 186 (1948).
- A. A. Vansheidt, The mechanism of formation and the structure of phenol-aldehyde plastics. *Akad. Nauk SSSR* **1**, 20 (1943).
- L. Vereschagin, V. Derevitskaya, and Z. Rogovin, Process of polymerization of methyl methacrylate at extremely high pressures. *J. Phys. Chem. (USSR)* **21**, 233 (1947).
- C. Walling and E. R. Briggs, The thermal polymerization of methyl methacrylate. *J. Am. Chem. Soc.* **68**, 1141 (1946).
- C. Walling, E. R. Briggs, and F. R. Mayo, The kinetics of the thermal polymerization of styrene. *J. Am. Chem. Soc.* **68**, 1145 (1946).
- R. H. Wiley and N. R. Smith, Preparation and polymerization of *m*-cyanostyrene. *J. Am. Chem. Soc.* **70**, 1560 (1948).
- R. H. Wiley and N. R. Smith, Nitrostyrenes. I. Polymerization of *m*-nitrostyrene. *J. Polymer Sci.* **3**, 444 (1948).

301.2 Emulsion and Solution Polymerization

- G. B. Bachman, H. B. Hass, and E. J. Kahler, Emulsion polymerizations at low temperatures. *Ind. Eng. Chem.* **41**, 135 (1949).
- P. D. Bartlett and K. Nozaki, Polymerization of allyl compounds. IV. Emulsion polymerization of allyl acetate. *J. Polymer Sci.* **3**, 216 (1948).
- J. H. Baxendale, M. G. Evans, and J. K. Kilham, Polymerization of methyl methacrylate in aqueous emulsions. *J. Polymer Sci.* **1**, 466 (1946).
- J. H. Baxendale, M. G. Evans, and J. K. Kilham, Polymerization of methyl methacrylate in aqueous solution. *Trans. Faraday Soc.* **42**, 668 (1946).
- R. G. Beaman, Anionic chain polymerization. *J. Am. Chem. Soc.* **70**, 3115 (1948).
- F. A. Bovey and I. M. Kolthoff, The mechanism of emulsion polymerizations. III. Oxygen as a comonomer in the emulsion polymerization of styrene. *J. Am. Chem. Soc.* **69**, 2143 (1947).
- E. I. Carr and P. H. Johnson, Non-aqueous emulsion polymerization systems. *Ind. Eng. Chem.* **41**, 1588 (1949).
- M. L. Corrin, Kinetic treatment of emulsion polymerization. *J. Polymer Sci.* **2**, 257 (1947).
- R. Deanin, R. D. Lindsay, and S. E. Leventer, Carbonatotetraminocobaltic nitrate activation of butadiene-styrene emulsion copolymerization. *J. Polymer Sci.* **3**, 421 (1948).
- P. P. Eley and A. W. Richards, The kinetics of ionic polymerizations. I. Polymerization of vinyl octyl ether catalyzed by iodine. *Trans. Faraday Soc.* **45**, 425 (1949); II. Polymerization of vinyl octyl ether catalyzed by stannic chloride and other catalysts, **45**, 436 (1949).
- M. G. Evans, Polymerization of monomers in aqueous solution. *J. Chem. Soc.* **1947**, 266.
- M. G. Evans and N. Uri, Photochemical polymerization in aqueous solution. *Nature* **164**, 404 (1949).
- H. E. Fierz-David and H. Zollinger, Vinyl chloride and its polymerization products. III. Polymerization of vinyl chloride in solutions. *Helv. Chim. Acta.* **28**, 1197 (1945).
- C. M. Fontana and G. A. Kidder, Kinetics of the polymerization of propylene with aluminum bromide-hydrogen bromide catalyst. *J. Am. Chem. Soc.* **70**, 3745 (1948).

- R. L. Frank, P. V. Smith, F. E. Woodward, W. B. Reynolds, and P. J. Canterino, Mercaptan structure and regulator activity in emulsion polymerization. *J. Polymer Sci.* **3**, 39 (1948).
- V. J. Frilette and W. P. Hohenstein, Polymerization of styrene in soap solutions. *J. Polymer Sci.* **3**, 22 (1948).
- G. Goldfinger, Polyphenyl. *J. Polymer Sci.* **4**, 93 (1949).
- W. Graulich and W. Becker, The influence of regulators on the emulsion polymerization of butadiene. *Makromol. Chem.* **3**, 53 (1949).
- R. A. Gregg, D. M. Alderman, and F. R. Mayo, Chain transfer in the polymerization of styrene. V. Polymerization of styrene in the presence of mercaptan. *J. Am. Chem. Soc.* **70**, 3740 (1948).
- O. Hagger, New catalysts for the polymerization of ethenes at room temperature. *Helv. Chim. Acta* **31**, 1624 (1948).
- W. D. Harkins, General theory of the reaction loci in emulsion polymerization. II. *J. Chem. Phys.* **14**, 47 (1946).
- W. D. Harkins, A general theory of the mechanism of emulsion polymerization. *J. Am. Chem. Soc.* **69**, 1428 (1947).
- E. A. Hauser and E. Perry, Emulsion polymerization of styrene. *J. Phys. & Coll. Chem.* **52**, 1175 (1948).
- R. N. Haward, Polymerization of methyl isopropyl ketone in cyclohexanone. *J. Polymer Sci.* **3**, 10 (1948).
- R. N. Haward, Polymerization in a system of discrete particles. *J. Polymer Sci.* **4**, 273 (1949).
- J. T. Hayes, A. E. Drake, and Y. T. Pratt, Disproportionated rosin soap in GR-S polymerization. *Ind. Eng. Chem.* **39**, 1129 (1947).
- W. P. Hohenstein and H. Mark, Polymerization of olefins and diolefins in suspension and emulsion. I. *J. Polymer Sci.* **1**, 127 (1946). II. **1**, 549 (1946).
- C. Horrex and F. T. Perkins, Inhibition of the low-temperature polymerization of isobutene. *Nature* **163**, 486 (1949).
- T. Iguchi, S. Kanegae, and H. Saito, Mechanism of emulsion polymerization for synthetic rubbers of the chloroprene type. I. Surface tension of chloroprene. II. Generation of chloroprene emulsion. *J. Soc. Chem. Ind. Japan* **47**, 837 (1944).
- T. Iguchi and H. Saito, Mechanism of emulsion polymerization for synthetic rubbers of the chloroprene series. III. Qualitative consideration on mechanism of emulsion polymerization. *J. Soc. Chem. Ind. Japan* **47**, 888 (1944).
- A. J. Johanson, F. L. McKennon, and L. A. Goldblatt, Emulsion polymerization of myrcene. *Ind. Eng. Chem.* **40**, 500 (1948).
- A. J. Johanson and L. A. Goldblatt, Emulsion copolymerization of isoprene and styrene. *Ind. Eng. Chem.* **40**, 2086 (1948).
- W. Kern, Redox catalysts in the polymerization of unsaturated compounds. *Makromol. Chem.* **1**, 249 (1947).
- W. Kern, Catalytic auto-oxidation and metallic auto-oxidation in polymerization of unsaturated compounds. *Makromol. Chem.* **2**, 48 (1948).
- P. M. Khomikovskii, Mechanism of emulsion polymerization. Polymerization of vinyl cyanide and of methyl methacrylate in water and soap solutions. *Doklady Akad. Nauk SSSR* **60**, 615 (1948).
- P. M. Khomikovskii and S. Medvedev, Mechanism of the emulsion polymerization. I. Polymerization of vinyl cyanide in aqueous solutions. *J. Phys. Chem. (USSR)* **22**, 1027 (1948).
- E. F. Kluchesky and L. B. Wakefield, Polymerization inhibition and stopping agents. *Ind. Eng. Chem.* **41**, 1768 (1949).
- I. M. Kolthoff and F. A. Bovey, Studies of retarders and inhibitors in the emulsion polymerization of styrene. I. Retarders. *J. Am. Chem. Soc.* **70**, 791 (1948).
- I. M. Kolthoff and W. J. Dale, The mechanism of emulsion polymerizations. II. The effect of oxygen on the emulsion polymerization of styrene. *J. Am. Chem. Soc.* **69**, 441 (1947).
- I. M. Kolthoff and W. J. Dale, Combination of potassium ferricyanide, diazothio ether and mercaptan as "catalyst" for emulsion polymerizations of butadiene and styrene. *J. Polymer Sci.* **3**, 400 (1948).
- I. M. Kolthoff, L. S. Guss, D. R. May, and A. I. Medalia, Determination of persulfate in emulsion polymerization latices. *J. Polymer Sci.* **1**, 340 (1946).

- C. Koningsberger and G. Salomon, Preparation and properties of rubber-like high polymers. III. Polymerization of mixtures in emulsion. *J. Polymer Sci.* **1**, 364 (1946).
- H. S. Lilley, Use of monoreactive phenol alcohols as models for the general polymerization of phenyl resin systems. *J. Soc. Chem. Ind. (London)* **67**, 196 (1948).
- H. Logemann and W. Becker, Activation of butadiene in emulsion polymerization. *Makromol. Chem.* **3**, 31 (1949).
- D. N. Marquardt, R. H. Porrier, and L. B. Wakefield, Polymerization of monomers in Buna S-3 system. *Ind. Eng. Chem.* **41**, 1475 (1949).
- C. S. Marvel, R. Deanin, B. M. Kuhn, and G. B. Landes, Reduction activation of emulsion copolymerization of butadiene and styrene. II. Different organic peroxides and reducing activators in presence and absence of metals. *J. Polymer Sci.* **3**, 433 (1948).
- C. S. Marvel, R. Deanin, C. G. Overberger, and B. M. Kuhn, Reduction activation of emulsion copolymerization of butadiene and styrene: The benzoyl peroxide-ferrous pyrophosphate system. *J. Polymer Sci.* **3**, 128 (1948).
- C. S. Marvel, G. E. Inskeep, R. J. Dearborn, J. H. Saunders, H. W. Johnston, D. A. Shepherd, A. J. Deutschman, J. A. Damman, and A. L. Oppegard, Use of cobalt complexes as activators in emulsion copolymerization of butadiene and styrene. *J. Polymer Sci.* **3**, 181 (1948).
- C. S. Marvel and C. D. Lewis, *n*-Octyl mercaptan as modifier for emulsion polymerization at high temperature. *J. Polymer Sci.* **3**, 354 (1948).
- C. S. Marvel, J. L. R. Williams, and H. E. Baumgarten, Emulsion polymerization of 2-alkyl-1,3-butadienes. *J. Polymer Sci.* **4**, 583 (1949).
- W. C. Mast and C. H. Fisher, Emulsion polymerization of acrylic esters and other vinyl monomers. *Ind. Eng. Chem.* **41**, 790 (1949).
- F. Masuo, Polymerization of butadiene by sodium. II. Properties of the polymer. *J. Soc. Chem. Ind. Japan* **48**, 54 (1945).
- F. Masuo and S. Hattori, Polymerization of butadiene. I. *J. Soc. Chem. Ind. Japan* **47**, 580 (1944).
- D. R. May and I. M. Kolthoff, Determination of disappearance of bis-isopropyl xanthogen ("Dixie") in synthetic rubber latex during polymerization. *J. Polymer Sci.* **4**, 735 (1949).
- A. I. Medalia and I. M. Kolthoff, Redox recipes. I. Reaction between ferrous iron and peroxides. General considerations. *J. Polymer Sci.* **4**, 377 (1949).
- E. J. Meehan, Composition of butadiene-styrene copolymers prepared by emulsion polymerization. *J. Polymer Sci.* **1**, 318 (1946).
- E. J. Meehan, Variation of monomer pressure with degree of conversion in emulsion polymerization of butadiene and of butadiene-styrene. *J. Am. Chem. Soc.* **71**, 628 (1949).
- I. Miyagawa and M. Nakamura, Synthetic rubber of the chloroprene type. VI. Emulsion condensation of chloroprene. *J. Soc. Chem. Ind. Japan* **47**, 835 (1944).
- A. A. Morton and M. L. Brown, Polymerization. II. Acid-salt interchange and chain branching in sodium polymerization of dienes. *J. Am. Chem. Soc.* **69**, 160 (1947).
- A. A. Morton, M. L. Brown, and E. Magat, Polymerization. III. An examination of low molecular weight products from the reaction of amylsodium with dienes. *J. Am. Chem. Soc.* **69**, 161 (1947).
- A. A. Morton and E. L. Little, Jr., Polymerization. X. Metalation of alkylaryl hydrocarbons and their use in the polymerization of butadiene. *J. Am. Chem. Soc.* **71**, 487 (1949).
- A. A. Morton and H. E. Ramsden, Polymerization. VIII. The action of metalating reagent on rubber. *J. Am. Chem. Soc.* **70**, 3132 (1948).
- A. A. Morton, R. P. Welcher, F. Collins, S. E. Penner and R. D. Coombs, Polymerization. IX. Metalation during alfin polymerization of butadiene and the formation of gel. *J. Am. Chem. Soc.* **71**, 481 (1949).
- M. Morton and R. V. V. Nicholls, Tertiary thiols as modifiers in GR-S polymerizations. *Can. J. Research* **25 B**, 159 (1947).
- J. Murata, Polymerization of chloroprene. I. Change in η_{sp}/c in the polymerization reaction. II. Action of solvent. III. Relation between the polymerization and the internal pressure of solvent. *J. Soc. Chem. Ind. Japan* **47**, 338 (1944).

- S. Nakaya, M. Naito, and G. Sawada, Studies on vinyl chloride resin. II. Polymerization of vinyl chloride in solution. Sumitomo Denki Iho (Sumitomo Elec. Bul.) No. 29, 53 (1943).
- R. G. W. Norrish and K. E. Russell, Friedel-Crafts catalysts in polymerization. Kinetic measurements and the role of water. *Nature* 160, 543 (1947).
- D. C. Pepper, Friedel-Crafts polymerization. I. Effect of solvent on the polymerization of olefines by stannic chloride. *Trans. Faraday Soc.* 45, 397 (1949); II. The kinetics of polymerization of styrene by stannic chloride. 45, 404.
- L. H. Perry, Solvent polymerization of isoprene and styrene-isoprene. *Ind. Eng. Chem.* 41, 1438 (1949).
- P. H. Plesch, Friedel-Crafts polymerizations. *Research* 2, 267 (1949).
- N. Rabjohn, R. J. Dearborn, W. E. Blackburn, G. E. Inskeep, H. R. Snyder, and C. S. Marvel, Emulsion polymerization at high temperature. *J. Polymer Sci.* 2, 488 (1947).
- L. W. Rainard, Effect of silver salts on emulsion polymerization systems containing butadiene. *J. Polymer Sci.* 2, 16 (1947).
- M. W. Rigg and R. Rosenthal, Ethyl sorbate in the diene synthesis. *J. Am. Chem. Soc.* 71, 2865 (1949).
- J. J. Sanderson and C. R. Hauser, Base catalyzed polymerization of styrene. *J. Am. Chem. Soc.* 71, 1595 (1949).
- W. A. Schulze and W. W. Crouch, Solution viscosity of GR-S. *Ind. Eng. Chem.* 40, 151 (1948).
- G. W. Scott and H. W. Walker, Viscosity changes in chloroprene emulsion polymerization. *Ind. Eng. Chem.* 41, 194 (1949).
- R. Sengupta and R. S. Palit, Potassium persulfate as initiator of polymerization in solution. *Current Sci. (India)* 18, 206 (1949).
- G. Smets, C. Masquelier, and F. Van Tornout, Solution and bulk polymerization of methyl methacrylate. *Bul. soc. chim. Belges.* 57, 493 (1948).
- G. Smets and P. Reiske, Polymerization of methyl methacrylate in the presence of catalysts and solvents containing chlorine. *Bul. soc. chim. Belges* 56, 159 (1947).
- W. V. Smith, Regulator theory in emulsion polymerization. I. Chain transfer of low-molecular-weight mercaptans in emulsion and oil phase. *J. Am. Chem. Soc.* 68, 2059 (1946).
- W. V. Smith, The partition of acrylonitrile between styrene and water. *J. Am. Chem. Soc.* 70, 2177 (1948).
- W. V. Smith, The kinetics of styrene emulsion polymerization. *J. Am. Chem. Soc.* 70, 3695 (1948).
- W. V. Smith, Chain initiation in styrene emulsion polymerization. *J. Am. Chem. Soc.* 71, 4077 (1949).
- W. V. Smith and H. N. Campbell, Detection of radio-active persulfate fragments in emulsion polymerized styrene. *J. Chem. Phys.* 15, 338 (1947).
- W. V. Smith and R. H. Ewart, Kinetics of emulsion polymerization. *J. Chem. Phys.* 16, 592 (1948).
- H. R. Snyder, J. M. Stewart, R. E. Allen, and R. J. Dearborn, The mechanism of modifier action in the GR-S polymerization. I. *J. Am. Chem. Soc.* 68, 1422 (1946).
- H. W. Spodheim, W. J. Badgley, and R. B. Mesrobian, Polymerization-degradation of styrene in solution. *J. Polymer Sci.* 3, 410 (1948).
- A. B. Steel, A. B. Boese, and M. F. Dull, A study of the polymerization products of diketene. *J. Org. Chem.* 14, 460 (1949).
- S. L. Talmud, R. M. Galding, and V. Y. Aldakushkin, Mechanism of polymerization of butadiene in water emulsions. *J. Gen. Chem.* 17, 739 (1947).
- K. Torii, Y. Oshima, E. Toyama, and S. Yoshikawa, Emulsion polymerization of vinyl acetate. I. Emulsion polymerization under various conditions. II. Solubility of vinyl acetate in water. III. Action of persulfate on the polymerization of vinyl acetate. IV. Polymerization of vinyl acetate in aqueous solution. V. Collection of powdered polyvinyl acetate from emulsion. *J. Soc. Chem. Ind. Japan* 49, 20 (1946).
- E. Trommsdorff, H. Köhler, and P. Lagally, Polymerization of methyl methacrylate. *Makromol. Chem.* 1, 169 (1947).
- E. J. Vandenberg and G. E. Hulse, Cumene hydroperoxide in redox emulsion polymerization. *Ind. Eng. Chem.* 40, 932 (1948).

- F. T. Wall, F. W. Banes, and G. D. Sands, The mechanism of modifier action in GR-S polymerization. II. *J. Am. Chem. Soc.* **68**, 1429 (1946).
- F. T. Wall, R. W. Powers, G. D. Sands, and G. S. Stent, Properties of polymers as functions of conversion IV. Composition studies of rubber-like copolymers. *J. Am. Chem. Soc.* **70**, 1031 (1948).
- F. T. Wall and T. J. Swoboda, An oxidation-reduction cycle in emulsion polymerization systems. *J. Am. Chem. Soc.* **71**, 919 (1949).
- C. Waller, The use of S35 in measurement of the transfer constant. *J. Am. Chem. Soc.* **70**, 2561 (1948).
- R. H. Wiley, Introduction to polymer laboratory experiments. Granular polymerization of methyl methacrylate. *J. Chem. Education* **25**, 204 (1948).
- A. I. Yurzhenko and M. Kolechkova, Mechanism of the polymerization of hydrocarbons in emulsions. *Compt. rend. acad. sci. URSS* **47**, 348 (1945).
- T. I. Yurzhenko, G. N. Gromova, and V. B. Khaitsier, Investigation of various types of peroxides as initiators of emulsion polymerization. *J. Gen. Chem. (USSR)* **16**, 1505 (1946).

301.3 Copolymerization

- P. Agron, T. Alfrey, Jr., J. Bohrer, H. Haas, and H. Wechsler, Experimental study of copolymerization. II. *J. Polymer Sci.* **3**, 157 (1948).
- T. Alfrey, Jr., Relative reactivities in vinyl copolymerization. *J. Polymer Sci.* **2**, 101 (1947).
- T. Alfrey, Jr., L. Arond, and C. G. Overberger, Acid-catalyzed copolymerization behavior of anethole. *J. Polymer Sci.* **4**, 539 (1949).
- T. Alfrey, Jr., and S. Greenberg, Experimental study of copolymerization. III. Copolymerization behavior of polychloroethylenes. *J. Polymer Sci.* **3**, 297 (1948).
- T. Alfrey, Jr., and V. Hardy, Chain-transfer in copolymerization reactions. *J. Polymer Sci.* **3**, 500 (1948).
- T. Alfrey, Jr., and J. G. Harrison, The copolymerization of styrene and allyl chloride. *J. Am. Chem. Soc.* **68**, 299 (1946).
- T. Alfrey, Jr., and S. L. Kapur, Copolymerization of some further monomer pairs. *J. Polymer Sci.* **4**, 215 (1949).
- T. Alfrey, Jr., and C. Lewis, Side-chain copolymerization. *J. Polymer Sci.* **4**, 767 (1949).
- T. Alfrey, Jr., F. R. Mayo, and F. T. Wall, Symbols for copolymerization. *J. Polymer Sci.* **1**, 581 (1946).
- T. Alfrey, Jr., E. Merz, and H. Mark, Experimental study of copolymerization. *J. Polymer Sci.* **1**, 37 (1946).
- E. J. Arlman, H. W. Melville, and L. Valentine, The copolymerization of styrene and methyl methacrylate, styrene and butyl acrylate. *Rec. trav. chim.* **68**, 945 (1949).
- C. H. Bamford and M. J. S. Dewar, The general kinetics of copolymerization and an extension of the viscosity method to determine velocity constants. *J. Chem. Phys.* **17**, 1188 (1949).
- P. D. Bartlett and K. Nozaki, The polymerization of allyl compounds. III. The peroxide-induced copolymerization of allyl acetate with maleic anhydride. *J. Am. Chem. Soc.* **68**, 1495 (1946).
- J. W. Breitenbach and H. P. Frank, Nonhomogenous polymers. *Monatsh.* **78**, 293 (1948).
- E. C. Chapin, G. E. Ham, and R. G. Fordyce, Copolymerization. IV. The validity of the tripolymer equation for the systems: styrene-vinyl chloride-methyl acrylate and styrene-vinyl chloride-acrylonitrile. *J. Am. Chem. Soc.* **70**, 538 (1948).
- E. C. Chapin, G. E. Ham, and C. L. Mills, Copolymerization. VII. Relative rates of addition of various monomers in copolymerization. *J. Polymer Sci.* **4**, 597 (1949).
- K. W. Doak, Copolymerization. VI. The copolymerization of chloroethylenes with other monomers. *J. Am. Chem. Soc.* **70**, 1525 (1948).
- R. E. Florin, Note on Friedel-Crafts copolymerization. *J. Am. Chem. Soc.* **71**, 1867 (1949).
- R. G. Fordyce and E. C. Chapin, Copolymerization. I. The mechanism of emulsion copolymerization of styrene acrylonitrile. *J. Am. Chem. Soc.* **69**, 581 (1947).

- R. G. Fordyce and G. E. Ham, Copolymerization. II. The mechanism of emulsion copolymerization of styrene and itaconic acid. *J. Am. Chem. Soc.* **69**, 695 (1947).
- R. G. Fordyce, Copolymerization. III. Mechanism of emulsion copolymerization of styrene and acrylonitrile. *J. Am. Chem. Soc.* **69**, 1903 (1947).
- R. G. Fordyce, E. C. Chapin, and G. E. Ham. Copolymerization. V. Relative monomer addition rates in vinyl copolymerization. *J. Am. Chem. Soc.* **70**, 2489 (1948).
- R. G. Fordyce and G. E. Ham, Copolymerization. VI. Mechanism of emulsion polymerization. *J. Polymer Sci.* **3**, 891 (1948).
- R. L. Frank, C. E. Adams, J. R. Blegen, R. Deanin, and P. V. Smith, Effect of impurities on copolymerization of isoprene and styrene. *Ind. Eng. Chem.* **39**, 887 (1947).
- R. L. Frank, C. E. Adams, J. R. Blegen, P. V. Smith, A. E. Juve, C. H. Schroeder, and M. M. Goff, Copolymerization of butadiene with vinyl monomers. *Ind. Eng. Chem.* **40**, 420 (1948).
- R. L. Frank, C. E. Adams, J. R. Blegen, P. V. Smith, A. E. Juve, C. H. Schroeder, and M. M. Goff, Substituted vinylpyridenes as monomers for synthetic elastomers. *Ind. Eng. Chem.* **40**, 879 (1948).
- R. L. Frank, J. R. Blegen and A. Deutschman, Jr., Aroyl disulfides as promoter-modifiers for copolymerization of butadiene and styrene. *J. Polymer Sci.* **3**, 58 (1948).
- R. L. Frank, J. R. Blegen, G. E. Inskeep, and P. V. Smith, Effects of impurities on copolymerization of butadiene and styrene. *Ind. Eng. Chem.* **39**, 893 (1947).
- R. L. Frank, S. Stevens, P. V. Smith, Jr., and C. Stevens, Mercaptan derivatives as modifiers in the copolymerization of butadiene and styrene. *J. Polymer Sci.* **3**, 50 (1948).
- L. M. Gindin, A. D. Abkin, and S. S. Medvedev, Binary copolymerization. *Compt. rend. acad. sci. URSS* **56**, 177 (1947).
- G. Goldfinger and T. Kane, Derivation of the copolymerization equation without steady-state assumptions. *J. Polymer Sci.* **3**, 462 (1948).
- G. Goldfinger and M. Steidlitz, Temperature dependence of copolymerization. *J. Polymer Sci.* **3**, 786 (1948).
- J. C. Hillyer, S. Swadesh, M. L. Leslie, and A. P. Dunlap, Butadiene-furfural copolymers. *Ind. Eng. Chem.* **40**, 2216 (1948).
- P. H. Johnson and R. L. Bebb, Anionic redox activation of butadiene-styrene copolymerization. *J. Polymer Sci.* **3**, 389 (1948).
- P. H. Johnson, R. R. Brown, and R. L. Bebb, Anionic oxidation reduction activation of butadiene-styrene copolymerization. Effect of subzero polymerization on polymer properties. *Ind. Eng. Chem.* **71**, 1617 (1949).
- S. L. Kapur, Copolymerization kinetics. *J. Sci. Ind. Research* **7**, 477 (1948).
- I. M. Kolthoff and W. E. Harris, Mercaptans as promoters and modifiers in emulsion copolymerization of butadiene and styrene using potassium persulfate as catalyst. I. Mercaptans as promoters. *J. Polymer Sci.* **2**, 41 (1947); II. Mercaptans as modifiers, **2**, 49 (1947); III. Calculation of molecular weights and intrinsic viscosities of polymers from mercaptan consumption data, **2**, 72 (1947); IV. Definition and calculation of modifier efficiency, **2**, 82 (1947).
- F. Leonard, W. P. Hohenstein, and E. Merz, Copolymerization rate constants in the system 2,5-dichlorostyrene-methyl acrylate. *J. Am. Chem. Soc.* **70**, 1283 (1948).
- F. M. Lewis and F. R. Mayo, Copolymerization. IX. A comparison of some cis and trans isomers. *J. Am. Chem. Soc.* **70**, 1533 (1948).
- F. M. Lewis, C. Walling, W. Cummings, E. R. Briggs, and F. R. Mayo, Copolymerization. IV. Effects of temperature and solvents on monomer reactivity ratios. *J. Am. Chem. Soc.* **70**, 1519 (1948).
- F. M. Lewis, C. Walling, W. Cummings, E. R. Briggs, and W. J. Wenisch, Copolymerization. VII. Copolymerization of some further monomer pairs. *J. Am. Chem. Soc.* **70**, 1527 (1948).
- C. E. Lowry and G. W. Stanton, Ternary polymers of vinylidene chloride and butadiene. *Ind. Eng. Chem.* **41**, 146 (1949).
- C. S. Marvel, W. J. Bailey, and G. E. Inskeep, Sodium catalyzed copolymerization of 1,3-butadiene and styrene. *J. Polymer Sci.* **1**, 275 (1946).

- C. S. Marvel, R. Deanin, C. J. Claus, M. B. Wyld, and R. L. Seitz, Hydrogen peroxide as catalyst for emulsion polymerization of butadiene and styrene. *J. Polymer Sci.* **3**, 350 (1948).
- C. S. Marvel and N. A. Higgins, Inhibiting effects of certain phenols on GR-S polymerization. *J. Polymer Sci.* **3**, 448 (1948).
- C. S. Marvel, G. E. Inskeep, R. Deanin, D. W. Hein, P. V. Smith, J. D. Young, A. E. Juve, C. H. Schroeder, and M. M. Goff, Copolymers of butadiene with alkyl, aryl, alkoxyl, and phenoxy styrenes. *Ind. Eng. Chem.* **40**, 2371 (1948).
- C. S. Marvel and N. S. Rao, Polymers and copolymers of *o*-acetoxystyrene and *o*-hydroxystyrene. *J. Polymer Sci.* **4**, 709 (1949).
- C. S. Marvel and J. L. R. Williams, Copolymers of 1,3-butadiene and 2,3-dimethyl-1,3-butadiene. *J. Polymer Sci.* **4**, 265 (1949).
- F. R. Mayo, F. M. Lewis, and C. Walling, Copolymerization. VIII. The relation between structure and reactivity of monomers in copolymerization. *J. Am. Chem. Soc.* **70**, 1529 (1948).
- F. R. Mayo, C. Walling, F. M. Lewis, and W. F. Hulse, Copolymerization. V. Some copolymerizations of vinyl acetate. *J. Am. Chem. Soc.* **70**, 1523 (1948).
- H. W. Melville, B. Noble, and W. F. Watson, Copolymerization. I. Kinetics and some experimental considerations of a general theory. *J. Polymer Sci.* **2**, 229 (1947); II. Molecular weight distribution and mean molecular weights in copolymerization systems, **4**, 629 (1949).
- K. Nozaki, Reactivity of monomers in copolymerization. *J. Polymer Sci.* **1**, 455 (1946).
- C. C. Price, Mechanism of vinyl polymerizations. IX. Some factors affecting copolymerization. *J. Polymer Sci.* **1**, 83 (1946).
- C. C. Price, Some relative monomer reactivity factors. *J. Polymer Sci.* **3**, 772 (1948).
- W. A. Schulze and W. W. Crouch, Composition of butadiene-styrene copolymers from sodium-catalyzed polymerization. *J. Am. Chem. Soc.* **70**, 3891 (1948).
- W. A. Schulze, W. W. Crouch, and C. S. Lynch, Butadiene-styrene elastomers from sodium-catalyzed copolymerizations. *Ind. Eng. Chem.* **41**, 414 (1949).
- R. Simha and L. A. Wall, Copolymerization. *J. Research NBS* **41**, 521 (1948) RP1937.
- W. Simpson, Polymerization of allyl esters. *J. Soc. Chem. Ind.* **65**, 107 (1946).
- I. Skeist, Copolymerization: The composition distribution curve. *J. Am. Chem. Soc.* **68**, 1781 (1946).
- G. Smets and A. Reckers, Polymerization and copolymerization of *m*-nitrostyrene. *Rec. trav. chim.* **68**, 983 (1949).
- L. K. J. Tong and W. O. Kenyon, Heats of polymerization. IV. Copolymerization. *J. Am. Chem. Soc.* **71**, 1925 (1949).
- S. N. Ushakov, Copolymerization of unsaturated cellulose derivatives. *Akad. Nauk SSSR* **1**, 35 (1943).
- S. N. Ushakov and S. P. Mitsengendler, Copolymerization of mixtures of vinyl esters with maleates. I. Copolymerization of ethylene glycol maleate with vinyl formate. *J. Applied Chem. (USSR)* **20**, 1261 (1947).
- L. A. Wall, Reactivity ratios in diene and diene-vinyl copolymerization. *J. Polymer Sci.* **2**, 542 (1947).
- C. Walling, Copolymerization. XIII. Over-all rates in copolymerization. Polar effects in chain initiation and termination. *J. Am. Chem. Soc.* **71**, 1930 (1949).
- C. Walling, E. R. Briggs, K. B. Wolfstirn, and F. R. Mayo, Copolymerization. X. The effect of meta- and para-substitution on the reactivity of the styrene double bond. *J. Am. Chem. Soc.* **70**, 1537 (1948).
- C. Walling, E. R. Briggs, and K. B. Wolfstirn, Copolymerization. XI. Copolymerizations involving α -vinyl pyridene, α -vinylthiophene, *o*-chlorostyrene, and α -methylstyrene. *J. Am. Chem. Soc.* **70**, 1543 (1948).
- C. Walling, D. Seymour, and K. B. Wolfstirn, Copolymerization. XII. The effect of *m*- and *p*-substitution on the reactivity of α -methylstyrene toward the maleic anhydride type radical. *J. Am. Chem. Soc.* **70**, 1544 (1948).
- C. Walling and F. R. Mayo, A note on the "alternating effect" in copolymerization. *J. Polymer Sci.* **3**, 895 (1948).

- G. C. Whitnack, Polarographic determination of free monomer in heteropolymerization reaction mixtures. *Anal. Chem.* **20**, 658 (1948).
 G. Williams and H. Thomas, Short-chain polymerization of styrene in presence of stannic chloride and HCl. *J. Chem. Soc.* **1948**, 1867.

301.4 General

- E. Abel, The kinetics of polymerization by means of hydrogen peroxide. *Monatsh.* **80**, 186 (1949).
 T. Alfrey, Jr., and C. Lewis, Heat of polymerization. *J. Polymer Soc.* **4**, 221 (1949).
 R. G. R. Bacon, Reduction activation. A new polymerization technique. *Trans. Faraday Soc.* **42**, 140 (1946).
 C. H. Bamford and M. J. S. Dewar, Determination of the velocity constants in the polymerization of vinyl compounds. *Nature* **157**, 845 (1946).
 C. H. Bamford and M. J. S. Dewar, Studies in polymerization. I. A method for determining the velocity constants in polymerization reactions and its application to styrene. *Proc. Roy. Soc. (London) A* **192**, 309 (1948); II. A method for investigating the relations between the molecular weights and intrinsic viscosities of polymers, and its application to polystyrene, *A192*, 329 (1948).
 C. H. Bamford and M. J. S. Dewar, Frequency factors in radical reactions. *Nature* **163**, 256 (1949).
 F. W. Banes and L. T. Eby, Quantitative determination of some inhibitors in polymers by ultra-violet-light absorption. *Ind. Eng. Chem. Anal. Ed.* **18**, 535 (1946).
 J. Bardwell and C. A. Winkler, The formation and properties of three-dimensional polymers. I. Statistics of network polymers; II. Network formation. *Can. J. Research* **27 B**, 116 (1949).
 J. H. Baxendale and M. G. Evans, Velocity constants of the propagation and termination steps in polymerization reactions. *Trans. Faraday Soc.* **43**, 210 (1947).
 J. H. Baxendale, M. G. Evans, and G. S. Park, Mechanism and kinetics of the initiation of polymerization by systems containing hydrogen peroxide. *Trans. Faraday Soc.* **42**, 155 (1946).
 R. F. Boyer, R. S. Spencer, and R. M. Wiley, Use of density-gradient tube in the study of high polymers. *J. Polymer Sci.* **1**, 249 (1946).
 J. W. Breitenbach and H. Schneider, The kinetics of the inhibition of polymerization reactions. *Monatsh.* **78**, 1 (1948).
 S. E. Bresler, The polar properties of molecules with conjugated double bonds and the mechanics of the polymerization process. *Akad. Nauk SSSR* **1**, 16 (1943).
 S. E. Bresler, Phenomenon of the lower limit in the low-temperature polymerization of hydrocarbons. *Compt. rend. acad. sci. URSS* **47**, 410 (1945).
 G. M. Burnett and H. W. Melville, Effect of environment on the reactivity of high polymers. *Nature* **158**, 553 (1946).
 G. M. Burnett and H. W. Melville, Determination of the velocity coefficients for polymerization processes. I. The direct photopolymerization of vinyl acetate. *Proc. Roy. Soc. (London) A* **189**, 456 (1947).
 G. M. Burnett, L. Valentine, and H. W. Melville, Spatial interference in polymerization reactions. *Trans. Faraday Soc.* **45**, 960 (1949).
 A. Chapiro, Polymerization by γ -rays. I. *Compt. rend.* **228**, 1490 (1949); II, 229, 827.
 F. C. Collins and G. E. Kimball, Diffusion-controlled reaction rates. *J. Colloid Sci.* **4**, 425 (1949).
 F. C. Collins and G. E. Kimball, Diffusion-controlled reactions in liquid solutions. *Ind. Eng. Chem.* **41**, 2551 (1949).
 F. S. Dainton and K. J. Ivin, Reversibility of the propagation reaction in polymerization processes and its manifestation in the phenomenon of a "Ceiling Temperature." *Nature* **162**, 705 (1948).
 G. Daletskii, A new class of inhibitors. Polymerization retarders. *J. Phys. Chem. (USSR)* **21**, 231 (1947).
 K. G. Denbigh, Velocity and yield in continuous-reaction systems. *Trans. Faraday Soc.* **40**, 352 (1944); II. The kinetics of steady state polymerization, **43**, 648 (1947).

- J. C. Devins and C. A. Winkler, The mechanism of popcorn polymer formation. *Can. J. Research* **26 B**, 356 (1948).
- R. D. Dunlop and F. E. Reese, Continuous polymerization in Germany. *Ind. Eng. Chem.* **40**, 654 (1948).
- M. G. Evans, J. Gergely, and E. C. Seaman, Factors influencing the activation energies of reactions involving double bonds and radicals. *J. Polymer Sci.* **3**, 866 (1948).
- P. J. Flory, Molecular size distribution in three dimensional polymers. V. Post-gelation relationships. *J. Am. Chem. Soc.* **69**, 30 (1947).
- P. J. Flory, Chain structure of vinyl and diene polymers in relation to polymerization mechanism. *J. Polymer Sci.* **2**, 36 (1947).
- W. M. Garrison, On the polymerization of unsaturated hydrocarbons by ionizing radiations. *J. Chem. Phys.* **15**, 78 (1947).
- A. I. Goldberg, Preparation of high-molecular-weight addition polymers. *Ind. Eng. Chem.* **39**, 1570 (1947).
- R. G. Heiligmann, Ionic polymerization of mono-olefinic hydrocarbons at low temperatures. A review of proposed mechanisms. *J. Polymer Sci.* **4**, 183 (1949).
- D. H. Hey and G. S. Misra, Arylazotriarylmethanes and tetraarylsuccinic dinitriles as catalysts in addition polymerization. *J. Chem. Soc.* **45**, 1807 (1949).
- K. Hultsch, The theory of the setting (hardening) of poly-condensation type resins. *Angew. Chem.* **61**, 93 (1949).
- H. H. G. Jellinek, Note on "inhomogeneity" of polymers. *J. Polymer Sci.* **4**, 399 (1949).
- W. Kern, Effect of molecular oxygen on the polymerization of unsaturated compounds. *Makromol. Chem.* **1**, 199 (1947).
- W. Kern, Redox systems as accelerators in the polymerization of unsaturated compounds. *Makromol. Chem.* **1**, 209 (1947).
- W. Kern, Initiation of polymerizations of unsaturated compounds catalyzed by peroxides. *Makromol. Chem.* **1**, 229 (1947).
- W. Kern, The polymerization of unsaturated compounds in biological reactions. *Makromol. Chem.* **2**, 63 (1948).
- M. S. Kharasch, W. Nudenberg, E. V. Jensen, P. E. Fischer, and D. L. Mayfield, Inhibition of polymerization. *Ind. Eng. Chem.* **39**, 830 (1947).
- V. V. Korshak and K. K. Samplanskaya, Role of stereochemical factors in polymerization processes. *Doklady Akad. Nauk SSSR* **59**, 497 (1948).
- L. Küchler, The influence of chain transfer on the rate of polymerization. *Makromol. Chem.* **2**, 176 (1948).
- L. Küchler, Mechanism of vinyl polymerization. *Naturwissenschaften* **35**, 105 (1948); **II**, **35**, 144 (1948).
- Y. Landler, A study of the mechanism of ionic polymerization by means of radioactive indicators. *Rec. trav. chim.* **68**, 992 (1949).
- Y. Landler and M. Magat, Some preliminary results of styrene polymerization catalyzed by slow neutrons. *Bul. soc. chim. Belges* **57**, 381 (1948).
- S. Medvedev, O. Koritskaya, and E. Alekseeva, Free radicals in polymerization processes. *Acta Physicochim. URSS* **19**, 457 (1944).
- H. W. Melville, Polymerization of vinyl compounds in the gas and in the liquid phase. *J. Chem. Soc.* **1947**, 274.
- H. W. Melville, Quantitative aspects of free radical chemistry. *Nature* **160**, 778 (1947).
- E. Merz, T. Alfrey, Jr., and G. Goldfinger, Intramolecular reactions in vinyl polymers as a means of investigation of the propagation step. *J. Polymer Sci.* **1**, 75 (1946).
- E. Miller, I. Fankuchen, and H. Mark, Polymerization in the solid state. *J. Applied Phys.* **20**, 531 (1949).
- K. Myrbäck and L. G. Sillén, On the equilibrium state of a branched molecule. *Acta chem. Scand.* **3**, 190 (1949).
- A. N. Nikitina, Study of the polymerization process by the method of Fresnel diffraction. *Bul. acad. sci. URSS Ser. phys.* **12**, 650 (1948).
- V. V. Razumovskii, Theory of electron tautomerism. III. Electronic structure and polymerizability of organic compounds. *J. Gen. Chem. (USSR)* **18**, 1189 (1948).

- D. E. Roberts, W. W. Walton, and R. S. Jessup, Heats of combustion and solution of liquid styrene and solid polystyrene and heat of polymerization of styrene. *J. Research NBS* **38**, 627 (1947) RP1801; *J. Polymer Sci.* **2**, 420 (1947).
- Z. A. Rogovin and L. A. Tsaplina, Effect of the viscosity of the medium on the polymerization of vinyl compounds. *J. Applied Chem. (USSR)* **20**, 875 (1947).
- G. Salomon, Double-bond reactivity. I. Polar reactions. *Chem. Weekblad* **45**, 621 (1949); II. Reactions of radicals in polymerization. **45**, 693 (1949).
- G. Salomon, Polymerization induced by silver salts. *Rec. trav. chim.* **68**, 903 (1949).
- C. E. Schildknecht, A. O. Zoss, and F. Grosser, Ionic polymerization of some vinyl compounds. *Ind. Eng. Chem.* **41**, 2891 (1949).
- G. V. Schulz, Effect of polymerization inhibitors. *Makromol. Chem.* **1**, 94 (1947).
- G. V. Schulz, Classification of inhibitor and regulator action in polymerization. *Chem. Ber.* **80**, 232 (1947).
- G. V. Schulz and G. Harborth, A dilatometric method for observing the progress of polymerization. *Angew. Chem. A* **59**, 90 (1947).
- P. W. Selwood, Applications of magnetochemistry to polymers and polymerization. *J. Research NBS* **42**, 151 (1948).
- P. S. Shantarovich and S. S. Medvedev, Kinetics of polymerization of hydrocarbons with a conjugated bond. *J. Phys. Chem. (USSR)* **21**, 1163 (1947).
- L. G. Sillén and K. Myrbäck, Statistics of formation of branched molecules. *Svensk. Kem. Tid.* **55**, 294 (1943).
- L. G. Sillén and K. Myrbäck, Branched molecules. III. Calculation of distribution functions. *Svensk. Kem. Tid.* **55**, 354 (1943).
- S. Y. Sokolov, Use of supersonic vibrations for observation of physico-chemical processes. *J. Tech. Phys. (USSR)* **16**, 783 (1946).
- D. Swern, G. N. Billen, and C. R. Eddy, Chemistry of epoxy compounds. VI. Thermal polymerization of the isomeric 9,10-epoxystearic acids. *J. Am. Chem. Soc.* **70**, 1228 (1948).
- A. V. Tobolsky, F. Leonard, and G. P. Roesner, Use of polymerizable ring compounds in constant volume polymerization. *J. Polymer Sci.* **3**, 604 (1948).
- L. K. J. Tong and W. O. Kenyon, Heats of polymerization of some unsaturates. *J. Am. Chem. Soc.* **69**, 2245 (1947).
- L. K. J. Tong and W. O. Kenyon, Heats of polymerization. II. Some esters of α -methylacrylic acid. *J. Am. Chem. Soc.* **68**, 1355 (1946); III. Styrene and substituted styrenes, **69**, 1402 (1947).
- V. N. Tsvetkov and E. Frisman, Flow birefringence as a method of studying polymerization kinetics. *J. Phys. Chem. (USSR)* **21**, 261 (1947).
- C. Walling, D. Seymour, and K. B. Wolfstirn, The reaction of α -methylstyrene with thioglycolic acid. *J. Am. Chem. Soc.* **70**, 2559 (1948).
- C. C. Winding, Polymerization. *Ind. Eng. Chem.* **40**, 1643 (1948).

302. AGING, DEGRADATION, AND OXIDATION

- H. E. Albert, Effect of certain antioxidants in GR-S. Natural and accelerated aging. *Ind. Eng. Chem.* **40**, 1746 (1948).
- H. E. Albert, G. E. P. Smith, Jr., and G. W. Gottschalk, Effect of iron on aging of GR-S. *Ind. Eng. Chem.* **40**, 482 (1948).
- G. J. Van Amerongen, Oxidation of rubber and related olefins. *Chem. Weekblad* **45**, 674 (1949).
- K. Atsuki and I. Kagawa, Cellulose acetate. XIII. Influence of ripening temperature on hydrolysis velocity. XIV. Relation between the composition of ripening bath and the hydrolysis velocity. *J. Soc. Chem. Ind. Japan* **45**, 376 (1942); XV. Ripening of cellulose acetate with sulfuric acid as catalyst. XVI. Velocity of hydrolysis and its mechanism. XVII. Depolymerization of cellulose acetate during ripening. **45**, 434 (1942).
- G. B. Bachman, H. Hellman, K. R. Robinson, R. W. Finholt, E. J. Kahler, L. J. Filar, L. V. Heisey, L. L. Lewis, and D. D. Micucci, A new method of preparing substituted vinyl compounds. Depolymerization studies on vinyl polymers. *J. Org. Chem.* **12**, 108 (1947).

- C. H. Bamford and M. J. S. Dewar, Photosensitization by vat dyes. *Nature* **163**, 214 (1949).
- L. Bateman, Photolysis of rubber. *J. Polymer Sci.* **2**, 1 (1947).
- L. Bateman and G. Gee, A kinetic investigation of the photochemical oxidation by certain non-conjugated olefins. *Proc. Roy. Soc. (London) A* **195**, 376 (1948).
- L. Bateman and G. Gee, The determination of absolute rate constants in olefinic oxidations. *Proc. Roy. Soc. (London) A* **195**, 391 (1948).
- J. L. Bolland, Kinetic studies in the chemistry of rubber and related materials. I. The thermal oxidation of ethyl linoleate. *Proc. Roy. Soc. (London) A* **186**, 218 (1946).
- J. L. Bolland, Kinetic studies in the chemistry of rubber and related materials. VI. The benzoyl peroxide-catalyzed oxidation of ethyl linoleate. *Trans. Faraday Soc.* **44**, 669 (1948).
- J. L. Bolland and G. Gee, Kinetic studies in the chemistry of rubber and related materials. II. The kinetics of oxidation of unconjugated olefins. *Trans. Faraday Soc.* **42**, 236 (1946); III. Thermochemistry and mechanisms of olefin oxidation. **42**, 244 (1946).
- J. L. Bolland and P. Ten Have, Kinetic studies in the chemistry of rubber and related materials. IV. The inhibitory effect of hydroquinone on the thermal oxidation of ethyl linoleate. *Trans. Faraday Soc.* **43**, 201 (1947); VII. The mechanism of chain propagation in the oxidation of polyisoprenes, **45**, 93 (1949).
- B. B. S. T. Boonstra and G. J. Van Amerongen, Pyrolytic depolymerization of rubber into isoprene. *Ind. Eng. Chem.* **41**, 161 (1949).
- R. F. Boyer, A statistical theory of discoloration for halogen-containing polymers and copolymers. *J. Phys. & Colloid Chem.* **51**, 80 (1947).
- E. F. Casassa, Degradation of high polymers. *J. Polymer Sci.* **4**, 405 (1949).
- S. W. Chen, The photochemical degradation of polystyrene. *J. Phys. & Colloid Chem.* **53**, 486 (1949).
- F. G. Ciapetta, S. J. Macuga and L. N. Leum, Depolymerization of butylene polymers. *Anal. Chem.* **20**, 609 (1948).
- W. L. Davidson and I. G. Geib, Effects of pile bombardment on uncured elastomers. *J. Applied Phys.* **19**, 427 (1948).
- H. Deuel and H. Neukom, Cross-linking of sodium alginates by mustard gas. *J. Polymer Sci.* **4**, 755 (1949).
- E. E. Dickey and M. L. Wolfrom, A polymer-homologous series of sugar acetates from the acetylosis of cellulose. *J. Am. Chem. Soc.* **71**, 825 (1949).
- B. Dogadkin and Z. Tarasova, Structural changes in rubber by the action of molecular oxygen. II. Kinetics of the destructive solution of vulcanized rubber. *J. Gen. Chem. (USSR)* **17**, 1401 (1947).
- T. F. Doumani, R. F. Deering, and A. C. McKinnis, Depolymerization of butadiene dimer. *Ind. Eng. Chem.* **39**, 89 (1947).
- E. F. Evans and L. F. McBurney, Oxidative stability of cellulose derivatives. Ultraviolet light stability of ethylcellulose. *Ind. Eng. Chem.* **41**, 1256 (1949); Heat stability of cellulose acetate, **41**, 1260.
- V. W. Fox, J. G. Hendricks and H. J. Ratti, Degradation and stabilization of polyvinyl chloride. *Ind. Eng. Chem.* **41**, 1774 (1949).
- V. L. Frampton, R. P. Foley, and H. H. Webber, Photolysis of cotton cellulose. I. Production of carbon dioxide on irradiation with intense ultraviolet light. *Arch. Biochem.* **18**, 345 (1948).
- G. G. Freeman, A. J. Baillie, and C. A. Macinnes, Bacterial degradation of sodium carboxymethyl cellulose and methyl ethyl cellulose. *Chem. and Ind.* **1948**, 279.
- N. Grassie and H. W. Melville, Thermal degradation of polymethyl methacrylate. *Bul. soc. chim. Belges* **57**, 142 (1948).
- N. Grassie and H. W. Melville, The thermal degradation of polyvinyl compounds. I. A new type of molecular still. *Proc. Roy. Soc. (London) A* **199**, 1 (1949); II. The degradation of benzoyl peroxide catalyzed polymethyl methacrylates, **A199**, 14 (1949); III. The effect of inhibitors and end groups on the degradation of polymethyl methacrylate. **A199**, 24 (1949); IV. The thermal degradation of the methyl methacrylate copolymers with glycol dimethacrylate and acrylonitrile, **A199**, 39 (1949).

- E. E. Harris and A. A. Kline, Hydrolysis of wood cellulose with hydrochloric acid and sulfur dioxide and the decomposition of its hydrolytic products. *J. Phys. & Colloid Chem.* **53**, 344 (1949).
- S. Harrobin, R. G. A. New, and D. Taylor, The oxygen absorption of rubber vulcanizates in light. *Trans. Faraday Soc.* **42**, 252 (1946).
- E. J. Hart and M. S. Matheson, The quantum yield of oxidation of Hevea rubber and GR-S. *J. Am. Chem. Soc.* **70**, 784 (1948).
- F. S. H. Head, Formation of tartaric acid by oxidation and hydrolysis of oxycelluloses produced by dinitrogen tetroxide. *J. Chem. Soc.* **1948**, 1135.
- K. Hess and E. Steurer, Thermal or mechanical reaction in the vibratory milling of substances of high molecular weight. *Z. physik. Chem.* **193**, 234 (1944).
- E. Heuser, W. Shackley, A. Adams, and E. A. Grunwald, Acetylation of cellulose in phosphoric acid solution. *Ind. Eng. Chem.* **40**, 1500 (1948).
- E. Hultin, A simple equation for the viscosity and the rate constant of high polymer substances under depolymerization. *Acta chem. Scand.* **3**, 465 (1949).
- E. Husemann, Weak bonds in ramie fibers and their rate of splitting in hydrolytically degraded ramie cellulose. *Makromol. Chem.* **1**, 140 (1947).
- E. Husemann and M. Goecke, Weak bonds and their rate of splitting in oxidatively degraded cotton and ramie cellulose. *Makromol. Chem.* **2**, 298 (1948).
- V. I. Ivanov and E. D. Stakheeva-Kaverzneva, Atmospheric oxidation of cellulose in ammoniacal copper solution. *Bul. acad. sci. URSS, Classe sci. chim.* **1945**, 492.
- V. I. Ivanov and E. D. Stakheeva-Kaverzneva, Chemical transformation of macromolecules of cellulose under the influence of oxidizing agents. *Uspekhi. Khim.* **13**, 724 (1946).
- D. L. C. Jackson and W. S. Reid, Degradation of a vinylidene chloride copolymer in solution. *Nature* **162**, 29 (1948).
- H. H. G. Jellinek, Degradation of long-chain molecules. II. *Trans. Faraday Soc.* **44**, 345 (1948).
- H. H. G. Jellinek, Thermal degradation of polystyrene. I. *J. Polymer Sci.* **3**, 850 (1948); II, **4**, 1 (1949); III. Thermal degradation of polystyrene and polyethylene, **4**, 13 (1949).
- R. L. Kenyon, R. H. Hasek, L. G. Davy, and K. J. Broadbooks, Oxidation of cellulose. *Ind. Eng. Chem.* **41**, 2 (1948).
- G. M. Konkle, R. R. Selfridge, and P. S. Servais, Behavior of silastic on aging. *Ind. Eng. Chem.* **39**, 1410 (1947).
- A. S. Kuz'minskii, Kinetics of the thermal oxidation of a sodium-butadiene polymer. *J. Gen. Chem. (USSR)* **18**, 1054 (1948).
- A. S. Kuz'minskii, L. L. Shanin, T. G. Degteva, and K. A. Lapteva, Oxidation of polydienes. I. Methods of studying the kinetics of oxidation of rubber. *Kolloid Zhur.* **9**, 374 (1947); II. Change of the chemical properties of sodium-butadiene rubber on oxidation with molecular oxygen, **10**, 26 (1948).
- A. S. Kuz'minskii and L. L. Shanin, Oxidation of polydienes. III. Change of physical properties of sodium-butadiene rubber during oxidation with molecular oxygen. *Kolloid Zhur.* **10**, 212 (1948).
- H. F. Launer and W. K. Wilson, The photochemistry of cellulose. Effects of water vapor and oxygen in the far and near ultraviolet regions. *J. Am. Chem. Soc.* **71**, 958 (1949).
- J. LeBras and R. Hildenbrand, The protection of rubber against oxygen by a deactivation effect. *Compt. rend.* **223**, 724 (1946).
- S. L. Madorsky and S. Straus, High vacuum pyrolytic fractionation of polystyrene. *Ind. Eng. Chem.* **40**, 848 (1948).
- S. M. Madorsky, S. Straus, D. Thompson, and L. Williamson, Pyrolysis of polyisobutene (Vistanex), polyisoprene, polybutadiene, GR-S, and polyethylene in a high vacuum. *J. Research NBS* **42**, 499 (1949) RP1989; *J. Polymer Sci.* **4**, 639 (1949).
- E. Matsui and Y. Hatakeyama, Depolymerization of polystyrene by heat. *J. Soc. Chem. Ind. Japan* **46**, 1267 (1943).
- L. R. Mayo, R. S. Griffen, and W. N. Keen, Accelerated aging of neoprene compounds. *Ind. Eng. Chem.* **40**, 1977 (1948).
- L. F. McBurney, Oxidative stability of cellulose derivatives: Heat stability of ethylcellulose. *Ind. Eng. Chem.* **41**, 1251 (1949).

- P. A. McGee, W. F. Fowler, Jr., C. C. Unruh, and W. O. Kenyon, Investigation of the properties of cellulose oxidized by nitrogen dioxide. VI. The effect of alkali on the celluronic acids. *J. Am. Chem. Soc.* **70**, 2700 (1948).
- R. B. Mesrobian and A. V. Tobolsky, Some structural and chemical aspects of aging and degradation of vinyl and diene polymers. *J. Polymer Sci.* **2**, 463 (1947).
- R. B. Mesrobian and A. V. Tobolsky, Effect of chemical agents on heat deterioration of GR-S. *Ind. Eng. Chem.* **41**, 1496 (1949).
- G. Metzger and F. Sauerwald, A method for the investigation of the mechanism of degradation of high polymeric organic substances, especially fibers. *Naturwissenschaften* **35**, 190 (1948).
- W. J. Morris and R. Schnurmann, Mechanical degradation of large molecules. *Nature* **160**, 674 (1947).
- A. Münster and H. Haas, A new demonstration of weak bonds in the cellulose molecule. *Z. Naturforsch.* **3b**, 376 (1948).
- E. Pascu, Molecular structure of cellulose and starch. *J. Polymer Sci.* **2**, 565 (1947).
- S. L. Perti, S. K. Ranganathan, T. S. Subramanian, and L. R. Sud, Metallic oxides as barrier treatments for prevention of attack by light on cellulose. *Nature* **163**, 877 (1949).
- L. R. Pollack, R. E. McElwain, and P. T. Wagner, Oxygen absorption of vulcanizates. *Ind. Eng. Chem.* **41**, 2280 (1949).
- N. Rabjohn, C. E. Bryan, G. E. Inskeep, H. W. Johnson, and J. K. Lawson, A study of the structure of butadiene polymers by means of ozonolysis. *J. Am. Chem. Soc.* **69**, 314 (1947).
- F. W. Reinhart, Degradation of plastics. *SPE News* **4**, 3 (1948).
- G. Schmid and E. Beuttenmüller, The effect of temperature on the decomposition of linear macromolecules by ultrasonic waves. *Z. Elektrochem.* **50**, 209 (1944).
- G. Schmid and W. Poppe, Frequency dependence of the ultrasonic degradation of macromolecules. *Z. Elektrochem.* **53**, 28 (1949).
- G. V. Schulz, Kinetics of the degradation of cellulose and the structure of the "long period" of the cellulose molecule. *J. Polymer Sci.* **3**, 365 (1948).
- R. B. Seymour, Pyrolysis of high polymeric hydrocarbons. *Ind. Eng. Chem.* **40**, 524 (1948).
- L. G. Sillén, Kinetics of degradation of high polymers. *Svensk. Kem. Tid.* **55**, 221 (1943).
- L. G. Sillén, Calculations on the kinetics of degradation of high polymers. *Svensk. Kim Tid.* **55**, 266 (1943).
- G. S. Skinner and J. H. McNeal, Decomposition of elastomers at high temperatures. *Ind. Eng. Chem.* **40**, 2303 (1948).
- H. Sobue and H. Kawai, Depolymerization of linear high-molecular compounds. I. Depolymerization of polystyrene by supersonic waves. II. Velocities and limiting degrees of depolymerization of polystyrene. *J. Soc. Chem. Ind. Japan* **49**, 36 (1946).
- E. Steurer and K. Hess, The process of formation and the mechano-chemical degradation of high polymers by vibratory milling. *Z. physik. Chem.* **193**, 248 (1944).
- J. Tanaka, IV. Changes in molecular distribution of natural rubber by milling. V. Change in molecular distribution of neoprene by milling. VI. Change in molecular distribution of Perbunan by milling. *J. Soc. Chem. Ind. Japan* **47**, 688 (1944).
- R. L. Tichenor, The photochemical decomposition of cellulose acetate-butyrate. *J. Polymer Sci.* **1**, 217 (1946).
- M. C. Throdahl, Aging of elastomers. Comparison of creep with some conventional aging methods. *Ind. Eng. Chem.* **40**, 2180 (1948).
- L. A. Wall, Mass spectrometric investigation of the thermal decomposition of polymers. *J. Research NBS* **41**, 315 (1948).
- R. C. Waller, K. C. Bass, and W. E. Roseveare, Degradation of rayon tire yarn at elevated temperatures. *Ind. Eng. Chem.* **40**, 138 (1948).
- R. C. Waller and W. E. Roseveare, Fatigue failure of rayon tire cord. *J. Applied Phys.* **17**, 482 (1946).

- A. G. Ward, The diffusion of decomposition products through plastic materials. *Phil. Mag.* **39**, 621 (1948).
 H. Winn and J. R. Shelton, Effect of certain antioxidants in GR-S. *Ind. Eng. Chem.* **40**, 2081 (1948).

303. VULCANIZATION AND CROSS-LINKING

- P. V. Afanas'ev and S. E. Bresler, Vulcanization of cellulose materials. *Akad. Nauk SSSR* **2**, 120 (1944).
 J. C. Bevington and R. G. W. Norrish, The crosslinking of vinyl polymers by Friedel-Crafts catalysts. I. *J. Chem. Soc.* **1948**, 771; II. **1949**, 482.
 G. F. Bloomfield, Modern views on the chemistry of vulcanization changes. III. Reaction of sulfur with squalene and with rubber. *J. Polymer Sci.* **1**, 312 (1946).
 G. F. Bloomfield, The reaction of sulfur and sulfur compounds with olefinic substances. V. Rubber vulcanization. *J. Soc. Chem. Ind. (London)* **67**, 14 (1948); VI. Factors influencing cyclic sulfide formation in the reaction of sulfur with polyisoprenes, **68**, 66 (1949).
 G. F. Bloomfield, Cross-linking in polymeric systems. *Nature* **161**, 298 (1948).
 J. Chedin and R. Vandoni, The gelatinization of high polymers. *Mém. services chim. état. (Paris)* **33**, 205 (1947).
 Y. Conwell, G. P. Roeser, and A. V. Tobolsky, Preparation and vulcanization of liquid polyisoprene polymers. *J. Polymer Sci.* **4**, 309 (1949).
 B. Dogadkin, G. Bartenev, and N. Novikova, Vulcanization of rubber. VI. Variation of the modulus of two-dimensional extension caused by vulcanization of natural and butadiene-styrene rubbers. *Kolloid-Zhur.* **10**, 94 (1948).
 B. Dogadkin, B. Karmin, and I. Gol'berg, The kinetics and optimum state of vulcanization. I. Vulcanization of natural rubber. *J. Gen. Chem. (USSR)* **17**, 1070 (1947).
 E. H. Farmer and F. W. Shipley, Modern views on the chemistry of vulcanization changes. I. Nature of the reaction between sulfur and olefins. *J. Polymer Sci.* **1**, 293 (1946).
 M. Gordon, Adiabatic reaction kinetics of Buna-S vulcanization. *J. Polymer Sci.* **3**, 438 (1948).
 F. Halla and W. Schützner, The kinetics of indene polymerization. V. Reaction kinetics of the vulcanization of indenenes. *J. Polymer Sci.* **3**, 525 (1948).
 E. A. Hauser and D. S. Le Beau, Ultramicroscopy by incident light of the vulcanization of rubber. *J. Phys. & Colloid Chem.* **53**, 274 (1949).
 C. M. Hull, L. A. Weinland, S. R. Olsen, and W. G. France, Sulfur bond in vulcanizates. *Ind. Eng. Chem.* **40**, 513 (1948).
 E. F. Izard and P. W. Morgan, Synthesis of disulfide cross links in polyvinyl alcohol and cellulose derivatives. *Ind. Eng. Chem.* **41**, 617 (1949).
 I. Jullander and B. S. Blom-Sallin, Cross-linking of nitrocellulose studied with the ultracentrifuge and consistometer. *J. Polymer Sci.* **3**, 804 (1948).
 G. D. Kratz, H. H. Young, Jr., and I. Katz, Action of organic accelerators in vulcanization of rubber. *Ind. Eng. Chem.* **41**, 399 (1949).
 R. F. Naylor, Modern views on the chemistry of vulcanization changes. II. Role of hydrogen sulfide. *J. Polymer Sci.* **1**, 305 (1946).
 R. F. Naylor, The reaction of sulphur and sulphur compounds with olefinic substances. II. Mechanism of the reaction of hydrogen sulphide with mono-olefins, di-isoprenes, and rubber. *J. Chem. Soc.* **1947**, 1532.
 J. Rehner and P. J. Flory, Vulcanization reactions in butyl rubber. *Ind. Eng. Chem.* **38**, 500 (1946).
 I. C. Rush and S. C. Kilbank, Effect of moisture variations on curing rate of GR-S. *Ind. Eng. Chem.* **41**, 167 (1949).
 M. L. Selker and A. R. Kemp, Sulfur linkage in vulcanized rubber. *Ind. Eng. Chem.* **39**, 895 (1947); **40**, 1470 (1949).
 N. Sheppard and G. B. B. M. Sutherland, Some infra-red studies on the vulcanization of rubber. *Trans. Faraday Soc.* **41**, 261 (1945).
 N. Sheppard and G. B. B. M. Sutherland, The infra-red spectrum of vulcanized rubber and the chemical reaction between rubber and sulphur. *J. Chem. Soc.* **1947**, 1699.

- S. Sönnerskog, Some views on the gelation of aqueous solutions of ethyl cellulose on heating. *Acta Chem. Scand.* **2**, 523 (1948).
- A. Springer, Kinetics of the vulcanization reaction. *Monatsh.* **78**, 200 (1948).
- R. D. Stiehler and J. H. Wakelin, Mechanism and theory of vulcanization. *Ind. Eng. Chem.* **39**, 1647 (1947).
- B. M. Sturgis, A. A. Baum, and J. H. Trepagnier, Vulcanization of GR-S with halogen compounds. *Ind. Eng. Chem.* **39**, 64 (1947).
- H. A. Torrence, Vulcanization of neoprene with antimony trisulfide. *Ind. Eng. Chem.* **41**, 641 (1949).
- T. Urbanski, Cross-linking of cellulose esters. A preliminary note. *Bul. Soc. chim. Belges* **57**, 467 (1948).
- G. J. Van Veersen, Chemistry of the vulcanization of natural rubber. *Chem. Weekblad* **45**, 573 (1949).
- C. S. Wilkinson, Jr. and S. D. Gehman, Vulcanization at high pressures. *Ind. Eng. Chem.* **41**, 841 (1949).
- I. Williams, Vulcanization of rubber with sulfur. *Ind. Eng. Chem.* **39**, 901 (1947).
- R. L. Zapp, Polymeric unsaturation and relative rate of cross linkage. *Ind. Eng. Chem.* **40**, 1508 (1948).
- A. M. Zolotareva, The state of sulfur in vulcanized rubber. *J. Tech. Phys. (USSR)* **16**, 937 (1946).

304. OTHER REACTIONS

- P. Alexander and R. F. Hudson, The kinetics of the heterogeneous reaction between potassium permanganate and wool. *J. Phys. & Colloid Chem.* **53**, 733 (1949).
- P. Alexander, D. Gough, and R. F. Hudson, The reaction kinetics of wool with chlorine solutions. *Trans. Faraday Soc.* **45**, 1058 (1949).
- T. Alfrey, Jr., C. Lewis, and B. Magel, Intramolecular condensations in vinyl copolymers. *J. Am. Chem. Soc.* **71**, 3793 (1949).
- A. Banderet and B. Rånby, Action of caustic soda on cellulose in oxygen-free atmosphere. *Helv. Chim. Acta* **30**, 1190 (1947).
- C. E. H. Bawn, The structure and reactivity of free radicals. *J. Chem. Soc.* **1949**, 1042.
- G. Champetier and P. Clément, The mechanism of the hydration of cellulose and its derivatives. *Bul. soc. chim. Belges* **57**, 236 (1948).
- J. Chédin and A. Tribot, Topochemical reactions on cellulose. The mechanism of nitration. *Bul. soc. chim. Belges* **57**, 263 (1948).
- P. R. Choudhury, Cellulose acetate. III. *J. Indian Chem. Soc.* **24**, 271 (1947).
- J. Cycot, Ethylcellulose: a study of the ethylation of cellulose. *Mém. services chim. état (Paris)* **33**, 159 (1947).
- D. R. Dhingra and S. Dutta, Alcohol-soluble nitrocellulose. *J. Indian Chem. Soc., Ind. & News Ed.* **9**, 45 (1946).
- D. Fensom, A photoelectric study of the rate of gelatinization of nitro-cellulose in nitroglycerine. *Can. J. Research* **26 B**, 59 (1948).
- V. J. Frilette, J. Hanle, and H. Mark, Rate of exchange of cellulose with heavy water. *J. Am. Chem. Soc.* **70**, 1107 (1948).
- D. Frishman, L. Hornstein, A. L. Smith, and M. Harris, Reaction between wool and active chlorine. *Ind. Eng. Chem.* **40**, 2280 (1948).
- S. G. Gallo, H. K. Wiese, and J. F. Nelson, Unsaturation in isoprene-isobutylene copolymers. *Ind. Eng. Chem.* **40**, 1277 (1948).
- T. S. Gardner, β -Aminoethoxyl- and β -cyanoethoxyl-cellulose acetates. *J. Polymer Sci.* **1**, 289 (1946).
- A. Klebanskii and K. Chevychalova, Structure of polychloroprene as determined by ozonolysis. XI. *J. Gen. Chem. (USSR)* **17**, 941 (1947).
- A. L. Klebanskii, R. M. Sorokina, and Z. Y. Khavin, Splitting of hydrogen halides from dihalobutenes formed in the chlorination and the bromination of butadiene. I. Synthesis of α -chloro- and α -bromo-butadienes and their polymerization. *J. Gen. Chem. (USSR)* **17**, 235 (1947).
- P. P. Kobeko and E. K. Moskvina, Determination of unsaturation in butadiene synthetic rubber. *J. Applied Chem. (USSR)* **19**, 1143 (1946).
- I. M. Kolthoff, C. W. Carr, and B. J. Carr, Ethanol-toluene-water as a solvent mixture for the extraction of nonpolymer from GR-S. *J. Polymer Sci.* **2**, 637 (1947).

- I. M. Kolthoff and T. S. Lee, Use of perbenzoic acid in analysis of unsaturated compounds. II. Determination of external double bonds in synthetic rubbers. *J. Polymer Sci.* **2**, 206 (1947).
- I. M. Kolthoff, T. S. Lee, and C. W. Carr, Determination of polystyrene in GR-S rubber. *J. Polymer Sci.* **4**, 429 (1949).
- I. M. Kolthoff, T. S. Lee, and M. A. Mairs, Use of perbenzoic acid in analysis of unsaturated compounds. I. Preparation and stability of solutions of perbenzoic acid. *J. Polymer Sci.* **2**, 199 (1947); III. Results of determinations of external double bonds in synthetic rubbers, **2**, 220 (1947).
- H. A. Laitinen and J. S. Nelson, Determination of hydroperoxides in rubber and synthetic polymers. *Ind. Eng. Chem. Anal. Ed.* **18**, 422 (1946).
- K. Lauer, R. Jaks, and L. Skark, Information on xanthation of cellulose. *Kolloid-Z.* **110**, 26 (1945).
- T. S. Lee, I. M. Kolthoff, and M. A. Mairs, Determination of unsaturation of synthetic and natural rubbers by means of iodine monochloride. *J. Polymer Sci.* **3**, 66 (1948).
- C. Lewis and H. Haas, Intramolecular reactions in vinyl copolymers. *J. Polymer Sci.* **4**, 665 (1949).
- G. D. Louth, Determination of free carbon in compounded rubber and synthetic elastomers. *Anal. Chem.* **20**, 717 (1948).
- C. J. Malm, L. J. Tanghe, and B. C. Laird, Determination of primary hydroxyl groups in cellulose acetate by tosylation and iodination. *J. Am. Chem. Soc.* **70**, 2740 (1948).
- Y. Mamiya, Synthetic fibers. II. Hydrolysis of acrylonitrile with caustic soda. *J. Soc. Chem. Ind. Japan* **44**, 860 (1941).
- A. Meller, Reactivity of fibrous cellulose. *J. Polymer Sci.* **4**, 619 (1949).
- T. Petitpas and M. Mathieu, Solid-state reactions of organic polymers. *Bul. soc. chim. France* **1949**, D 43.
- Z. A. Rogovin, The mechanism of formation of alkali celluloses and cellulose xanthate. *Akad. Nauk SSSR* **1**, 33 (1943).
- R. M. Ross, The effect of heat and sodium sand upon sodium polybutadiene. *J. Am. Chem. Soc.* **71**, 1130 (1949).
- J. Rosset and R. Paris, Variation of the properties of cellulose acetate during the deacetylation by ammonia. *Compt. rend.* **228**, 920 (1949).
- A. Saffer and B. L. Johnson, Measurement of internal double bonds in polymers by perbenzoic acid addition. *Ind. Eng. Chem.* **40**, 538 (1948).
- N. Saito, Thermochemical study of some reactions of cellulose and its derivatives. I. Determination of the gross heat of reaction of acetylation of cellulose in the fibrous state. *J. Soc. Chem. Ind. Japan* **45**, 1122 (1942); II. The analysis of total heat of acetylation excluding initial heat of reaction, **45**, 1126 (1942); III. The thermal analysis of the acetylation reaction of cellulose in the fibrous state, **45**, 1128 (1942).
- H. Schnell, The titrimetric determination of carboxylic end groups in poly-amino caproic acids. *Makromol. Chem.* **2**, 172 (1948).
- G. E. Serniuk, F. W. Banes, and M. W. Swaney, A study of the reaction of buna rubbers with aliphatic mercaptans. *J. Am. Chem. Soc.* **70**, 1804 (1948).
- B. D. Sully, Detection of end groups in polymer molecules. *Nature* **159**, 882 (1947).
- M. Taniguchi and M. Hosono, Hydrolysis of cellulose triacetate by water vapor. *J. Soc. Chem. Ind. Japan* **48**, 92 (1945).
- A. V. Tobolsky, L. Castro, J. Stein, and A. Sacher, Polyisoprenes: A theory of the formation of terpenes and related compounds. *J. Polymer Sci.* **2**, 246 (1947).
- W. P. Utermohlen, Jr. and E. L. Wallace, Reaction of tetrachlorophthalic anhydride with cellulose derivatives. *J. Polymer Sci.* **2**, 275 (1947).
- A. A. Vasil'ev, The unsaturation of butadiene rubbers. *J. Gen. Chem. (USSR)* **17**, 923 (1947).
- D. Vermaas and P. H. Hermans, Course of acetylation and deacetylation reactions of cellulose fibers. I. Optical and swelling properties. *J. Polymer Sci.* **2**, 397 (1947); II. X-ray diagrams, **2**, 406 (1947).

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